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ECONOMIC GEOGRAPHY

OCTOBER

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LAND UTILIZATION IN CENTRAL ONTARIO
L. G. Reeds

CLARK UNIVERSITY, WORCESTER, MASSACHUSETTS, U.S.A.

OUR CONTRIBUTORS

Mr. Ward, Agricultural Economist in the Northern Great Plains regional office, Bureau of Agricultural Economics, United States Department of Agriculture, Lincoln, Nebraska, is primarily interested in regional studies of land utilization.

Mrs. Griess, whose field of special interest is Latin America, was trained in geography and geology at Smith College, the University of Nebraska and Pennsylvania State College, where she is at present Instructor in Geography. She has previously taught at the University of Nebraska, Miami University, and Winthrop College.

Doctor Davis has been professor of geography and head of his department in Marshall College since 1939. He participated in the survey of the T.V.A. area in 1935, and in the years since has done much field work in the Ohio Valley. He received his doctorate from the University of Chicago.

Doctor Miller, now head of the Department of Geography at Pennsylvania State College, previously taught for two years at Western Reserve and two years at Ohio State, and served afterward two years in the map division of the Office of Strategic Services. He received his graduate training at Ohio State and Nebraska.

Mr. Crain has been chairman of the Department of Geography at Denver University since he was discharged from the Navy at the close of World War II. He has done considerable advanced graduate study at Clark. His special interests are arid and semi-arid land use and agriculture, irrigation, and inter-American relations.

Mr. Reeds, lecturer in the Department of Geography at the University of Toronto from which he received his A.B. and A.M. degrees, served with the Royal Canadian Navy until his discharge in the fall of 1945, when he returned to Toronto to take up his present position. He is engaged in research and study for his doctorate under direction of the University staff, including Dr. D. F. Putnam, and Dr. Griffith Taylor.

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THE GREAT PLAINS

TO every distinctive environment man has made distinctive adjustments that characterize his culture within the compass of that environment. The High Plains of the United States and Canada, that broad piedmont grassland that extends from Peace River to the Rio Grande along the eastern slope of the Rockies, forms one of the world's most distinctive environments, an environment of semi-aridity, low humidity, clear skies, high elevation, broad horizons, and seas of waving grass, where antelope, elk and bison; prairie-dog, gopher, and ground-squirrel; coyote and cougar and wolf; Cheyenne and Comanche and Sioux and a score more of redman's linguistic stocks found forage and food and wild, free living.

The white explorer and missionary brought the horse to the High Plains and a new era of culture opened up for the Indian; the white fur-trader brought fire water, and firearms, and metal wares, and the Indian further changed his way of life. Then the white man brought cattle and sheep, and the flocks and herds grew to countless thousands, for the High Plains remained still a sea of waving grasses where pastoral nomadism and range life flourished. Then the white man brought the revolver, and barbed wire, and the plow, and tools for drilling artesian wells; he converted the range into croplands, the ranch into fields. Where once the cowboy rode the range and the covered wagon wound along the trails from station to station and from spring and stream to desert water-hole, the farmer followed his furrow and the steam locomotive and crowded trains sped over the rails. The Indian was gone, the cowboy disappearing, and a great agricultural industry producing protein in grain and meat for the world's industrial workers was developing, even while the last century waned.

Today the Great Plains have become the granary of our great nation, the larder upon which the peoples of the world have come to depend for their strength and health to do the world's work, and to rebuild the world's civilization after the ravages of the great war. Modern technology, modern economy, modern society have dramatically transformed the "Great American Desert" with its dearths and its hazards into one of the world's greatest and most trustworthy sources of provender and raw materials for man's weal, and ease, and safety. Thus have the Great Plains become safeguards of the Four Freedoms.

ECONOMIC GEOGRAPHY

VOL. 22 OCTOBER, 1946 No. 4

NORTHERN GREAT PLAINS AS PRODUCER OF WHEAT

Ralph E. Ward

THE Great Plains of North America extending from Texas to central Canada is one of the world's principal wheat producing regions. A great mid-continent belt varying from 200 to 800 miles in width, it has been settled and developed as a wheat and livestock-producing region in comparatively recent years. This article concerns itself with the central portion of the region, the Northern Great Plains of the United States, which extends from Kansas and Colorado to North Dakota and Montana. The Northern Great Plains region for this study consists of the states of North Dakota, South Dakota, Nebraska, Kansas, Montana, Wyoming and Colorado. Although the western part of this region includes a portion of the Rocky Mountains and the eastern part blends into the Central Lowlands, most of the wheat is grown in the central and truly Great Plains portion of the region. Hard red wheat is produced, with winter varieties the prevailing type as far north as central Nebraska and spring varieties farther north. The hard wheats bring top prices in the principal markets of the United States and in other parts of the world.

Development of wheat production in the Northern Plains is the result of experience and experimentation to overcome natural hazards and adapt farming to an unfamiliar environment. As homesteaders pushed westward into the Great Plains, they brought with them the farming methods and wheat varieties which they had used in other parts of the United States and in other countries. Some varieties, particularly those which had developed under the rigorous conditions in the Russian and Canadian wheat regions, were the basis for development of several of the present varieties. Farmers, with the aid of various agricultural services, adapted their farm practices and developed wheat varieties to resist natural hazards and take advantage of favorable conditions. Although natural hazards are high and a substantial acreage of wheat land has been returned to grazing in some localities, wheat production has undergone, over a relatively short period of 30 to 80 years, a successful adjustment to an unfamiliar environment.

LAND USE AND CHARACTERISTICS OF PLAINS' AGRICULTURE

Before starting an analysis of wheat producing areas, brief description of the major uses of land and the outstanding characteristics of Plains' agriculture is needed for understanding conditions under which wheat is grown.

Medium and short grasses were the predominant natural vegetation of the Plains, hence the earliest agricultural

use by white men was for grazing cattle and horses. A few settlers were plowing the native sod on the eastern fringe of the Plains by 1860, with oxen and horses for power. Two years later the Homestead Act marked the real beginning of settlement. This act, invention of barbed wire and the windmill, the improvement of the steel plow and other implements enabled settlers to push farther west and convert grassland to cropland. The tractor has been an important factor in establishing wheat production in the Plains in the past 20 to 30 years.

The acreage of cropland continued to increase until 1932 when 110 to 115 million acres were cropped or reported as summerfallow or idle cropland. The United States Census shows 105 million acres of cropland exclusive of wild hay in 1929, and Federal-State Statisticians of the Bureau of Agricultural Economics estimate an increase of 5 million acres of land in crops from 1929 to 1932 in the 7 Northern Plains States. From 1932 to 1939, the amount of land used for crop production decreased sharply, the amount of idle and fallow land increased and several million acres were abandoned or regrassed. From 1939 to 1944, the amount used for crop production increased substantially, but did not reach the former high point of 1932. Although some cropland which was regrassed and some native sod land were plowed during World War II, a substantial acreage of low-yielding cropland, estimated at 5 to 8 million acres, has remained as grazing despite favorable weather conditions and high prices for wheat.

At present, about 26 per cent of the total land area of the region is cropland, including fallow and idle, 66 per cent is grazing land, and 8 per cent is in non-

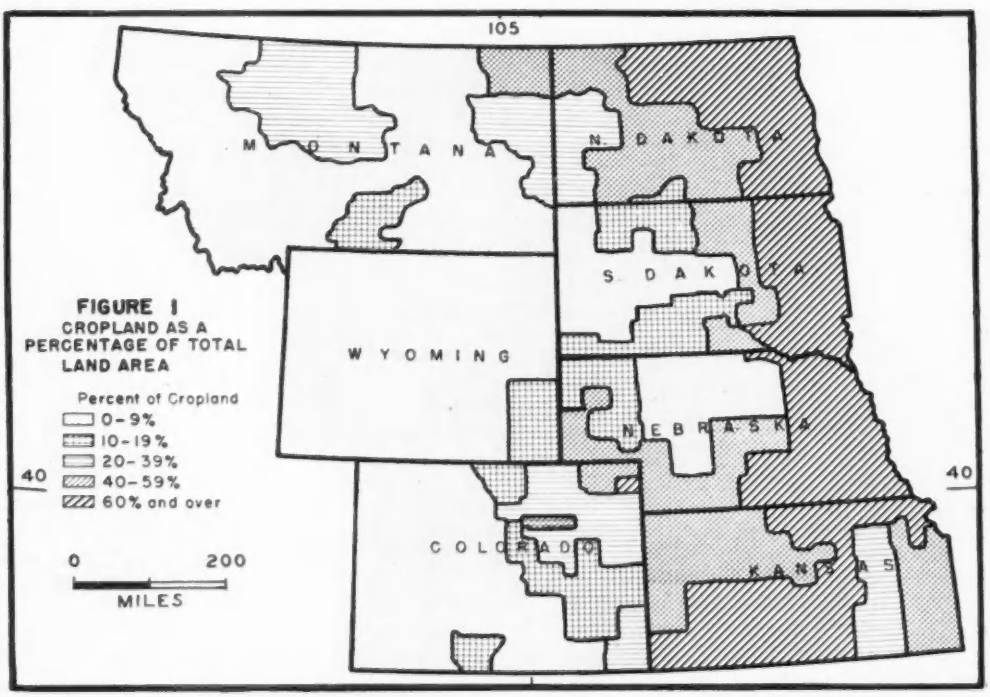

FIGURE 1.—Area in cropland declines from east to west, reflection of distribution of moisture, soils, and economic conditions. As population of America and demand for food increases, cropland farming will expand westward. Range and grazing country will lose ground to more intensive use of the land.

agricultural uses. Cropland is unevenly distributed, some counties having less than 1 per cent cropland while others have more than 80 per cent. The highest proportion is found in the eastern part of North Dakota, South Dakota, Nebraska and south-central Kansas where cropland is 60 per cent or more of the total land area (Figure 1).

In general, the proportion of cropland decreases from east to west, but not in regular belts. For example, the area with 40 to 60 per cent cropland, lying west of the area with more than 60 per cent, is broken by the sandhills of Nebraska and the grasslands of western South Dakota. Farther west the spottiness increases and islands of cropland of various sizes are intermingled with grazing areas. Much of the central part of the region, together with the mountainous portions of western Montana, Wyoming and Colorado, is essentially grazing and specialty crop area with less than 10 per cent cropland. Thus, the Plains merge on the eastern side with the more humid farming areas of the midwest, while westward with increasing aridity and a decreasing proportion of cropland, they rise gradually to high plateaus which end abruptly at the foot of the Rocky Mountains. West of the Continental Divide is a mountainous area with irrigated valleys, timber and grazing, where topography rather than climate becomes the dominant factor in determining agricultural use.

Scanty rainfall limits cropland in the central portion of the region to the most fertile soils, capable of storing moisture for later crop use. Since average rainfall is near the critical point for cereal crop production, such areas are subject to

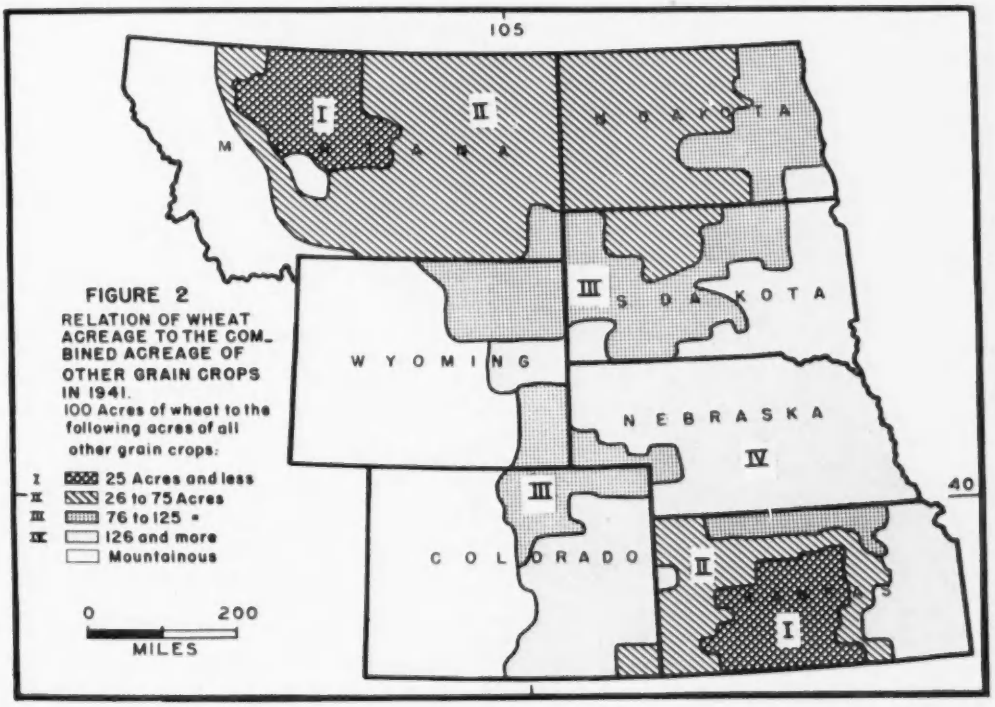
105
40
I
II
III
IV
M O N T A N A
N O R T H D A K O T A
S O U T H D A K O T A
W Y O M I N G
N E B R A S K A
C O L O R A D O
FIGURE 2
RELATION OF WHEAT ACREAGE TO THE COMBINED ACREAGE OF OTHER GRAIN CROPS IN 1941.
100 Acres of wheat to the following acres of all other grain crops:
I 25 Acres and less
II 26 to 75 Acres
III 76 to 125 "
IV 126 and more
Mountainous
0 200
MILES

FIGURE 2.—Distribution of wheat acreage in relation to other grain crops represents a distinctive pattern of land use, particularly significant in the economy of the Great Plains and their rank as producer of the nation's bread.

wide fluctuations in acreage that is planted to crops and wider fluctuations in production. Large amounts of level grasslands are not used for crops because of moisture limitations. Some land broken in the 1920's has been regrassed because it proved unprofitable for cropping.

Although the Plains cannot be adequately described in generalities, they may be said to form a region of extremes, with some characteristics which tend to set them apart from other regions. The climate is characterized by relatively light rainfall, wide variations in day to day and seasonal temperatures, low humidity and high wind movement. Most of the precipitation falls during the growing season, often in torrential thunderstorms. Summers are hot and hot winds are likely to damage crops in July and August. Winters are cold, particularly in the northern states, and the growing season is relatively short in the north and at high elevations. Elevation increases from 2,000 feet or less in the eastern portion to 5,000 to 7,000 feet on the high plateaus farther west. Topography varies from gently sloping to rolling, and rough, broken areas. Large expanses of land are topographically suitable for cultivation which must remain in native sod because of moisture limitations.

Economically the region is characterized by much greater agricultural production than can be consumed in the region, by long distance to markets, by competition with higher-yielding areas, by great variability in production, and by large acreage of marginal cropland. The Plains farmer is therefore vitally affected by conditions which influence his distant markets and by national

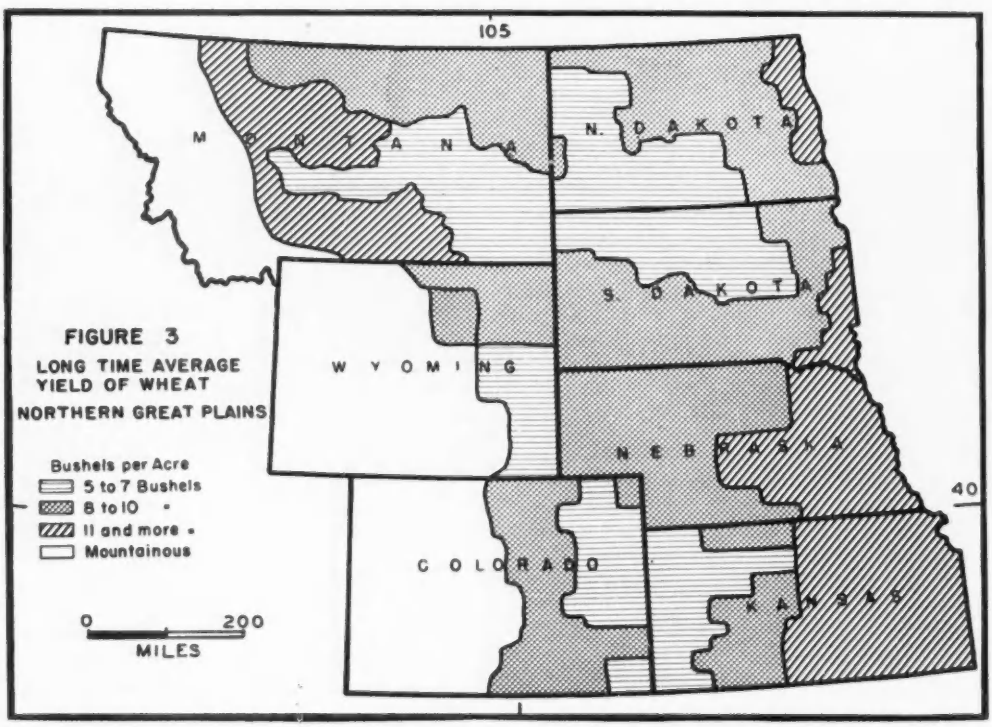

FIGURE 3.—Yield of wheat per acre, though reflecting in its broad outlines the same distributional pattern as the percentage of cropland in the total area, reveals significance of other important factors, such as soil type and texture.

programs, such as crop insurance and the ever-normal granary, which attempt to mitigate effects of wide variability in production.

Variability of production from year to year and from one locality to another is an outstanding characteristic. Rich land resources produce high yields of crops and grass during favorable periods and the widely heralded dust storms during the most unfavorable periods. Nutritious native grasses under favorable conditions support livestock both summer and winter, while in unfavorable seasons almost no grass is available even in the summer. In recent years, average wheat yields for the region as a whole have varied from 5 to 20 bushels per acre and production from 160 million to 580 million bushels. Variation in the high risk areas is much greater than the average for the region.

drouth recurs so frequently that, over a period of years, cultivation may not be profitable.

Diversity of land resources and rigorous climatic conditions posed problems in adjustment that were peculiar to the Plains. Adaptation of wheat varieties has been directed primarily toward development of such qualities as drouth resistance, winter hardiness and resistance to rust and smut together with the capacity to produce reasonably good yields of high quality wheat. Cultural practices such as summer fallow, strip cropping and contour farming came into use to conserve moisture and lessen erosion. Timeliness of farm operations has been found of major importance. A few days' difference in seeding or summer-fallowing may make a bushel or more per acre difference in yield. Timeliness of operations has been greatly

FIGURE 4.—Alternate strips of wheat and fallow in north-central Montana illustrate an important adaptation to the semiarid climate.

Geographically, differences in yield are almost as great as from year to year. Five bushels of wheat per acre is the long-time average yield for some counties as compared with 18 bushels in other dryland counties. Large areas are dependable producers of wheat, corn, other feed crops and livestock. At the other extreme is land that lies near the margin of crop production where high yields of wheat are produced occasionally, but

facilitated by tractor and combine (Figure 4).

That the diverse environment also contains much that is favorable to wheat production is evidenced by the high-quality, hard-red wheat which is produced. Among factors favorable to growth of wheat which are found to considerable degree in many parts of the Plains are enough fall moisture to start winter wheat, cool spring weather,

abundant sunshine and low humidity at ripening time. Level to gently undulating topography permits use of large-scale machinery, thus lowering cost of production. Soils are generally fertile and easily tilled.

DEVELOPMENT AND PRESENT IMPORTANCE OF WHEAT

In a comparatively short period of rapid settlement and expansion in a new environment, wheat production in the Northern Great Plains was developed from small acreage harvested by reaper or header to an average of 37 million acres of wheat produced with the aid of rubber-tired tractors and self-propelled combines. Approximately 3 million acres of wheat were harvested in the Northern Plains states in 1880 after almost two decades of experience in adapting wheat varieties and cultural methods to prevailing conditions. From 1880 to 1900, wheat acreage increased rapidly in North Dakota, South Dakota, Nebraska and Kansas. Another major increase in acreage from 1900 to 1920 took place with a wave of settlement in Montana, western North Dakota and South Dakota, and eastern Wyoming. The increase continued at a slower rate until 1930, when the acreage of wheat exceeded 37 million. Since 1930, the acreage of wheat has fluctuated from 29 to 42 million but with no sustained upward trend. Although wheat acreage fluctuates substantially from year to year, a degree of stability appeared in some states in the region as early as 1900. Only a small net increase has been made in the region as a whole since 1920. There was limited sod-breaking up to 1932.

In the United States as a whole, wheat acreage has fluctuated with changing conditions but no upward trend is apparent since 1910. While wheat acreage was increasing in the Plains, it was decreasing in the soft-red winter wheat region. During the 1920's an increasing proportion of wheat acreage was concentrated in the Plains. Since 1930, about 55 per cent of the United States acreage and 45 per cent of the production was in the Northern Plains region. The northern and southern Great Plains together have about 70 per cent of the United States acreage and 60 per cent of the production. From 1930 to 1944, acreage changes in the Plains followed about the same trend as in the United States as a whole, indicating some degree of balance among regions.

The seven Northern Great Plains states produced an average of 370 million bushels of wheat annually during the 16-year period, 1929–1944. Wheat sales are about 65 per cent of crop sales and 20 per cent of the value of all agricultural commodities sold. Meat, produced from the vast range areas and from the corn-belt fringe of the region, is the only agricultural product that exceeds wheat in value of sales.

PATTERN OF WHEAT ACREAGE

Wheat is more widely grown and probably more flexible in its use of cropland resources than any other grain crop in the Plains. Despite its wide adaptation, however, wheat acreage is highly concentrated in some areas, while in other areas wheat is grown on diversified farms with other competing grain crops. Farmers, in selecting crops which will bring the greatest net returns from the resources at hand, have concentrated the wheat acreage in areas that have a wide range in climate, soils, natural hazards and productivity.

The selection of land for growing wheat was not entirely on the basis of best natural adaptation of wheat as expressed in high yields per acre. In fact, the tendency is toward specialization in wheat in areas of lower than

average productivity. In some parts of the Plains, particularly the medium and low-yielding areas, wheat brings greater net returns than any other crop under natural and economic conditions that prevail there. Physical and economic conditions in the Northern Plains are such that farmers, in their selection of the most profitable crops, have adopted a varied cropping pattern which ranges from specialized wheat areas where wheat occupies most of the cropland, to diversified farming areas where wheat is only a minor crop.

Grains occupy 88 per cent of the land used for crops in the region and wheat occupies almost one-half of the grain crop acreage, a relationship that has remained fairly constant since 1929, with wheat acreage varying from 43 to 52 per cent of the acreage of all grain crops. Since the situation in 1941 was about average in this respect for the past 16 years, it was selected for analyzing the relation of wheat to other grain crops. Planted acreage data were used to avoid the influence of abnormal abandonment that might have occurred in some localities.

In 1941, the acreage planted to wheat varied from 93 per cent of the total grain crop acreage in some counties in the specialized wheat areas to less than 2 per cent in some counties in the diversified or cornbelt areas. To show the relationship, the region was divided into 4 sets of areas in which the wheat acreage was 84 per cent of the combined acreage of all grain crops in Area I; 67 per cent in Area II; 50 per cent in Area III; and 22 per cent in Area IV (Figure 2).

Area I in Montana and Kansas was the most highly specialized in wheat with more than four-fifths of the grain crop acreage planted to wheat. Moving away from such centers of wheat acreage, wheat occupies a somewhat less prominent position. The change is gradual in Montana and North Dakota and rapid in Kansas. Area II in Kansas is a narrow belt around Area I. In Montana and North Dakota, Area II is a large wheat and grass area. Area III occupies a belt east and south of Area II in the northern portion of the region. In the southern portion, change from wheat to corn or sorghums is so abrupt that very few counties appear in the group. The remainder of the region east of the mountains has less than 50 per cent of the grain crop acreage occupied by wheat and is labeled Area IV. The portions of Area IV where wheat competes most successfully with other grain crops are southern Nebraska, eastern Colorado and eastern Kansas. Corn gets first choice of use of land in a large part of Nebraska and the southeastern part of South Dakota. In some

TABLE I

RELATION OF WHEAT ACREAGE TO OTHER GRAIN CROPS BY AREAS, NORTHERN GREAT PLAINS, 1941

Areas[1]	*All Grain Crops*[2]	*Wheat*		*Corn*	*Other Grain Crops*
	1,000 Acres	*1,000 Acres*	*Per Cent*	*Per Cent*	*Per Cent*
I	8,931	7,488	84	2	14
II	18,535	12,362	67	6	27
III	14,243	7,049	50	16	34
IV	30,171	6,605	22	37	41

[1] Areas delineated according to the degree of specialization in wheat.
[2] Grain crops are wheat, corn, oats, barley, rye, flaxseed and grain sorghum. Planted acreage data were used.

Data compiled from records of Federal-State Statisticians and production capacity studies, Bureau of Agricultural Economics.

parts of Areas II and III most of the land is in grass and the wheat producing portions are "islands" where topography and soil are suitable for crop production under semiarid conditions. Of the crops that are produced, wheat is by far most important, and several million acres are planted in these range-livestock, wheat-producing areas.

From Area I to Area IV, wheat acreage as a percentage of the grain-crop acreage decreases from 84 to 22 per cent, while acreage of corn increases from 2 to 37 per cent and acreage of all other grain crops increases from 14 to 41 per cent (Table I).

More than three-fourths of the wheat acreage of the region is concentrated in Areas I, II and III where wheat is not only the leading crop but where its acreage equals or exceeds the combined acreage of all other grain crops combined (Table II). The three areas contain 27 million acres of wheat and 15 million acres of all other grain crops. In contrast, the 7 million acres of wheat in Area IV are outranked 3 to 1 by other grain crops.

Trends and fluctuations in the acreage of wheat from 1931 to 1941 in the various areas are noteworthy and economically significant. The trend was downward in the more specialized wheat areas, about sustained for the less specialized areas and upward for the diversified areas. Widest fluctuations were in more diversified areas where other grain crops are strong competitors of wheat. Changes in acreage are more sensitive to changes in price and cost relationships in areas where other crops can be substituted readily for wheat than in areas where no satisfactory alternatives are available. Another reason for shift in the diversified areas is that winter wheat is a more reliable crop than corn in times of drouth, whereas corn will usually bring greater net returns than wheat when rainfall is ample. During a dry period, such as 1934 to 1939, wheat is likely to be substituted for corn. During a period when rainfall is above average, such as 1940 to 1942, corn is likely to displace wheat.

In contrast, shifts in wheat acreage in the specialized wheat areas are made more slowly and with greater difficulty because of lack of satisfactory alternative enterprises. As wheat acreage was reduced during the 1930's, more cropland became idle in the specialized wheat areas than in the diversified areas. There are many impediments to a shift from wheat to other crops in the specialized areas. Although barley, sorghum or corn may produce as many feed units per acre as wheat in many of the wheat areas, the net return per acre is usually less and major changes would be necessary to shift to livestock

TABLE II

PROPORTION OF THE REGIONAL ACREAGE OF WHEAT AND OTHER GRAIN CROPS IN VARIOUS AREAS, NORTHERN GREAT PLAINS, 1941

Crops	*Region*	*Area I*[1]		*Area II*[1]		*Area III*[1]		*Area IV*[1]	
	1,000 Acres	*1,000 Acres*	*Per Cent*	*1,000 Acres*	*Per Cent*	*1,000 Acres*	*Per Cent*	*1,000 Acres*	*Per Cent*
Wheat	33,504	7,488	22	12,362	37	7,049	21	6,605	20
Other grains[2]	38,376	1,443	4	6,173	16	7,194	19	23,566	61

[1] Areas delineated according to degree of specialization in wheat, see Table I.
[2] Other grains are corn, oats, barley, rye, flaxseed and grain sorghum. Planted acreage data were used.

Data compiled from records of Federal-State Statisticians and production capacity studies, Bureau of Agricultural Economics.

production. The major use of land, kind of farm equipment, size of unit, storage facilities, marketing facilities, and experience of farm operators all center around wheat. In the localities containing high proportion of land near the margin of crop production, the only alternative to wheat may be a shift to grass production which requires major change in type of operation and much larger operating units.

AVERAGE YIELDS AND RISK FROM NATURAL HAZARDS

Long-time average yield of wheat for the Northern Plains is 10 bushels per planted acre. There are wide variations from the average yield, both geographically and from year to year. Long-time average yields in various areas illustrate and measure geographic differences. Year to year changes in yield, which are shown by a risk factor calculated from insurance premiums, illustrate and measure time variability. Both yield and risk factor are based on experience in production of wheat.

Under dryland conditions, where most wheat is grown, the long-time average yield of wheat varies from 5 bushels per planted acre in some counties to 18 in the more favorably located counties. Higher yields are obtained in a few counties affected by irrigation, but the acreage of wheat is small. The yield used is the adjusted average county yield established for the 1941 program of the Agricultural Adjustment Administration and the Federal Crop Insurance Corporation. The yields are based on all available information including "key" farm records from 1930 to 1940 and adjusted for a longer period. As a means of delimiting areas, three groupings were made as follows: counties with 5, 6 and 7 bushels per acre in a low-yielding group; counties with 8, 9 and 10 bushels per acre in a medium-yielding group; and counties with 11 bushels or more in a high-yielding group. A few isolated counties which did not conform to neighboring counties were arbitrarily attached to the nearest group. Such cases were so few as to have little or no bearing on the totals.

FIGURE 5.—A 20 bushel per acre crop of wheat in a favorable year in western South Dakota. Contour strips conserve moisture and reduce the hazard of crop failure in the dry years.

The low-yielding group covers large area in the north central and south central parts of the region (Figure 3).

Medium-yielding areas surround low-yielding areas and cover a large part of southern South Dakota and western Nebraska. High-yielding areas are along the eastern border and in central Montana. Although the areas are characterized by low, medium and high average yields, there is considerable variation in different localities within an area. The low-yielding areas, therefore, should not be designated as marginal, but they can be described as having a high proportion of the cropland near the margin of successful wheat production under economic conditions which have prevailed during the past 15 years.

Although rainfall probably is the most important factor influencing yield of wheat in the Plains, it is evident that soils, temperature, winds and other factors are also important. The low-yielding area which extends eastward from central Montana to a point about 100 miles short of the eastern border of South Dakota crosses rainfall zones ranging from 14 to 20 inches. Both north and south of this area average yields are higher in localities where average precipitation is the same (Figure 5).

Close relationship pertains between yield areas and variability of yields from year to year. Annual variability was measured by calculating risk factor from crop insurance premiums and by determining the coefficient of variation by areas.

Risk factor is percentage of long-time average yield which was required to pay crop insurance premium for the 1941 program. Since wheat crop insurance covered all natural hazards and premiums were based on the historical cost of insuring 75 per cent of the average yield, areas with greatest variability in annual yields would have the highest risk factor. The highest risk factor and therefore greatest risk from natural hazards was found in low-yielding areas. The average risk factor for areas of low yield was 28 per cent as compared with 20 per cent for areas of medium yield and 9 per cent for areas of high yield. Despite some exceptions to the general rule, relation of average yield to degree of risk from natural hazards is apparent both statistically and geographically. The risk factor, although a new measure and probably subject to revision, supplies a valuable indicator of relative variability in yields of wheat in different parts of the region. Data are now becoming available which will show the relative hazards under different types of operation such as summer fallow compared with continuous cropping.

As measured by the coefficient of variation, the yield of wheat is more variable in the Northern Plains than in the United States as a whole, and more variable in the low-yielding than in the other areas. The coefficients of variation for the 11-year period 1931–41 are as follows: United States, 21 per cent; Plains, 34 per cent; high-yielding area, 12 per cent; medium-yielding area, 50 per cent; and low-yielding area, 66 per cent. Since an 11-year period, the longest time for which area data were available, is relatively short, the coefficient of variation was calculated for a longer period for the region as a whole. The variation for the 16-year period 1929–44 was 40 per cent as compared with 34 per cent for the 11-year period 1931 to 1941. Although an 11-year period is too brief for accurate measure of variability, it does supplement crop insurance data by supplying additional evidence that annual variation in wheat yields is much greater in low, than in high-yielding areas.

During the 11-year period, 1931–41, yield of wheat was less than 50 per cent of average yield in 4 years in the

low-yielding area, 2 years in the medium-yielding area, and none in the high-yielding area. Frequency of extremely low yields probably was greater during this period than for a longer period because of severe drouths in the 1930's. Highest yield during the same period was 9 times greater than the lowest yield in the low-yielding area, 6 times greater in the medium-yielding area and less than 2 times greater in the high-yielding area. Variability in average yield of small areas is usually greater than for large areas because natural hazards sometimes affect only small localities in one year. Individual farm yields and experiment station plots show wider range in yield than average for the county in which they are located and counties usually have wider range in yield than areas in which they are located. Frequency of extremely low yields is reflected in high risk factor and high insurance rates.

Despite, or perhaps because of, conditions which cause low yields and high risk, wheat occupies a more prominent position in competition with other grain crops in areas of low yield. There, wheat occupies 56 per cent of the acreage of all grain crops, and in the medium and high-yielding areas, it occupies 49 to 39 per cent respectively. The proportion of the grain crop acreage planted to barley is greater in low than in high-yielding areas. Sorghum is grown in medium to low-yielding areas. Corn and oats, however, show the opposite tendency, that is, acreage is greatest in areas of highest productivity. Thus, chief competitors of wheat in low-yielding areas are barley and sorghum, and in high-yielding areas corn and oats.

Although wheat yields are high in the eastern part of South Dakota, Nebraska and Kansas, corn and other grains also yield well and the result is a diversified cropping pattern with corn receiving first choice in use of land. In areas farther west, both in the spring wheat area in North Dakota and Montana and the winter wheat area of western Kansas, western Nebraska and eastern Colorado, conditions are less favorable for production of both corn and wheat, but the relative advantage shifts from corn to wheat. Thus, wheat appears to have its greatest economic advantage over other grain crops where conditions are such as to bring only medium to low yields.

FIGURE 6.—Combining short wheat in a dry year in western Kansas. High protein wheat is produced at low cost with large, efficient machinery on level land.

Wheat has occupied a large acreage of land near the extensive margin of cultivation, where average yields are so low and risk from natural hazards is so high as to cast doubt on advisability of cul-

tivating land at all. High variability in yield increases difficulty of determining the extensive margin of cultivation. A county-average yield of 5 bushels per acre over a period of years may be composed of annual yields varying from practically nothing to 20 bushels per acre. Variation on individual farms is even greater, in many cases from complete crop failure to 40 bushels per acre. Furthermore, tendency for several consecutive years of favorable or unfavorable conditions seems apparent (Figure 6).

Trend in wheat acreage was significantly different in each of the yield groups for the 11-year period 1931–41. Although fluctuation and rate of change was greatest in high-yielding areas, trend for the period was definitely upward. In low-yielding areas, the trend was distinctly downward and in medium-yielding areas, slightly downward, in part due to overexpansion of wheat acreage on low-yielding land near the margin of crop production. In the process of adjustment, substantial acreage of cropland has been retired and diverted to grazing or left idle awaiting change in conditions which will justify cropping it again. The result of such adjustment has been increasing proportion of wheat acreage on medium and high-yielding land from 1931 to 1941, a tendency that reverses that which has prevailed in the Plains for many years. Although it probably is only a correction of past mistakes, much regrassing carries a strong indication of permanence.

Additional evidence of the tendency to grow wheat or leave the land idle in low-yielding areas, is shown from an analysis of data from the United States Census. Decrease in land used for crops from 1929 to 1939 was 28 per cent in low-yielding areas, 20 per cent in medium-yielding areas, and 10 per cent in high-yielding areas. Idle and fallow land increased 288 per cent, 176 per cent and 62 per cent for the low, medium and high-yielding areas respectively. Decrease in land reported either as cropped or idle was 5 per cent, 4 per cent and 2 per cent for low, medium and high-yielding areas respectively.

Although complete acreage data for the 4-year period 1942–45 have not been analyzed by areas, examination of a few samples indicates sharp increase in wheat acreage in all parts of the region. The 1945 wheat acreage for the region was slightly above average for the past 15 years and about 15 per cent below the all-time high acreage in 1938.

FUTURE PROSPECTS

The wheat farmer with aid of agricultural science has made many adjustments to variable environmental factors in the Plains. New varieties of wheat better resistant to drouth, winter-killing and rust are continually being developed. Summer fallow, contour and strip farming have come into extensive use to conserve moisture, prevent erosion, and increase yields. Large-scale machinery has lowered cost of production and increased timeliness of operations. All methods are subject to further improvement, more widespread use and better adaptation to Plains conditions. The ever-normal granary, crop insurance and methods of predicting chances of getting a crop by the amount of soil moisture at seeding time are promising efforts to avoid some of the risk from natural hazards.

The Plains must depend on national and world markets for its wheat. Use of wheat for human food in the United States, the main source of demand, has not varied greatly for many years. With increased population, consumption of wheat in the immediate postwar period is likely to be as high as, or higher than, prewar unless substantial dietary

changes occur. The other principal uses of wheat, feed and export, have been extremely variable and have been greatly influenced by national and international policies and programs.

Acreage of wheat in the United States and in the Plains, although substantially increased from the low acreage in 1942, is about average for the past 20 years. Average yield per acre probably is increasing with the result that greater total production is obtained from the same number of acres. Production of wheat in recent years has been substantially greater than consumption would be at prewar rates. The present scarcity of wheat in the United States is due to feeding large quantities to livestock during the war and the present abnormal demand from war-devastated countries. Unless export demand continues or the amount of wheat used for feed is increased, a substantial reduction in acreage will be needed after the present heavy demand has been met. A moderate reduction is probable even under optimistic assumptions regarding demand for wheat in the next 5 to 10 years.

Moderate reduction in wheat acreage would conform with adjustments needed from the viewpoint of soil conservation and efficiency of production. Conservationists have stressed the need for regrassing several million additional acres of cropland to reduce serious wind and water erosion. More rotation of grain crops with grass and hay crops is needed to maintain fertility. Even in the driest areas, some rotation is possible with crested wheat grass or other forage crops. Farm management specialists point out advantages of larger operating units to make more efficient use of modern machinery and lower the cost of production. Such practices, if put into effect, would tend to reduce acreage and increase yield per acre.

Acreage adjustments in response to changes in demand for wheat are likely to vary in different parts of the Plains. Diversified crop areas are more sensitive to price changes and to competitive position of other crops than are specialized wheat areas. Since corn and other feed crops produce more feed per acre than wheat in the diversified areas, strong demand for feed tends to reduce wheat acreage in such areas, and would tend to reduce competition between specialized wheat areas and diversified farming areas for the nation's production of wheat.

About one-fourth of the wheat acreage in the Northern Plains is in areas where average yield of wheat is 7 bushels or less per acre. Since no other crop is as profitable as wheat, farmers in such areas must depend upon their ability to compete for the wheat market. Extreme shifts in price and yield of wheat have caused great distress in such areas in the past. Policies which tend to minimize changes in price and yield and which provide incentives for regrassing and soil conservation would be helpful in the uncertain localities.

If major reduction in wheat acreage should become necessary, farmers in the low-yielding areas would be faced with expense of regrassing and the attempt to secure additional land before they can change from wheat to livestock. Such changes were found to be slow and difficult during the 1930's. Shifts to livestock production were much more frequent in localities where wheat acreage was interspersed with grassland than in areas where only a small amount of grassland was available.

If proper adjustments of a long time character to balance production with probable demand for wheat and to conserve land resources were made, two major problems of variability would remain: (1) high variability in production because of natural hazards, and

(2) high variability in prices paid to the wheat grower. Experience shows that yield of wheat varies greatly from year to year, particularly in low and medium-yielding areas. Price changes have been even greater and low prices have sometimes accompanied low yields with disastrous results to farmers' income.

The wheat farmer can do some things to tide over variations. Better practices will reduce, but by no means eliminate, variations in production. Cash reserves are needed for years of low income. Both problems, however, are largely beyond control of the individual farmer. One is the result of environment to which he can only adapt his operations. The other is due to economic forces largely beyond his, or any individual's control. Public programs, such as the ever-normal granary and crop insurance, have been designed to alleviate effects of variation in production and price. Programs in the future should deal not only with needed adjustments in land use, regrassing, and efficiency of operation, but also in providing aids to decrease variability or withstand its effects.

The Plains are difficult to understand and describe. Wide differences in distinctive geographic areas within the region have led to paradoxical descriptions which range from crediting the region as the nation's foremost cereal producer, to the recommendation that it never should have been, or be plowed. Both statements may be true of certain areas, but neither statement is truly descriptive of the region as a whole.

The Northern Great Plains region is an important producer of wheat and wheat is likely to remain its most important crop in the foreseeable future. Wheat contributed greatly to the settlement of the Plains, its cultivation has been successfully adapted to the environment, and it makes possible utilization of low-yielding land resources. In the future, some wheat areas in the Plains can withstand severe competition, some can shift to other crops, but some will be almost entirely dependent on high demand for wheat.

COLOMBIA'S PETROLEUM RESOURCES

Phyllis R. Griess

ALL regions of Colombia covered by sedimentary rocks are potentially petroliferous. Investigations are being carried on in the lower, middle and upper Magdalena River valley; the Atlantic and Pacific coastal plains; the Cesar River valley; the Colombian portion of the Maracaibo Basin; and in the foothills and adjacent plains on the eastern side of the Andes. Other regions of sedimentary rocks are basins within the Eastern Cordillera; the eastern plains, drained by headwaters of the Amazon and Orinoco river systems; and the rift valley between the Western and Central Cordilleras, drained by upper courses of the Cauca and Patía rivers. The total potentially petroliferous area is estimated to be about 30 per cent of the country; this figure, however, includes only that part of the Llanos or eastern plain which flanks the Andes mountains. If all the plain is included, as might well be since all is covered by sedimentary rocks, a much higher percentage of the total area of the country should be assigned to the potential petroleum producing regions. Present knowledge of the geology of much of the country is too scant to permit exact estimate of extent of possible oil-bearing formations.

History

Credit is given to Don Gonzalo Jiménez de Quesada and his followers for the discovery of petroleum in Colombia. In 1537, these men saw near Barrancabermeja in the Magdalena valley, "a bitumen fountain or boiling well," yielding a black, viscous liquid. What they saw was an oil seep, such as are found in several parts of the country. It was, however, merely the first time that such a seep had been seen in Colombia by Europeans, as the Indians had found the black, sticky fluid before the coming of the Spaniards. Spanish records state that the Indians used the material as an ointment "as it prevents them from being tired and fortifies their legs." Heaps of broken pottery, near these seeps, may indicate that the material was also employed by the natives as fuel for firing pottery.

Forgotten for almost four hundred years, it was not until the early part of the twentieth century that any important activity took place in the regions of Colombia's oil seeps. By this time, the world had become very conscious of oil; new discoveries in various parts of the world had stimulated interest in possible productive petroleum areas. Two concessions, the De Mares and the Barco, were granted in 1905 for exploration for, and exploitation of, petroleum; thus began the modern period in Colombian oil history. Granting of the two concessions was followed by periods of alternate essentially superficial activity and relative quietude. Periods of inactivity were due to difficulties of initiating exploratory work during World War I, general business conditions in world markets, necessity of drawing up statutes to regulate the oil industry in Colombia and testing of provisional laws.

Thus, the first concessions were developed very slowly. General Barco started

road building on his concession immediately after receiving his contract from the government and in 1906 began building a provisional refinery at Cúcuta, but he met so little success in his venture that he enlisted the aid of North American oil companies and their capital. Their efforts at development were little more successful than those of General Barco and it was not until the Texas Petroleum Company and the Socony-Vacuum Oil Company purchased the concession in 1936 that any real progress was made. In the De Mares Concession, geological surveying began in 1915, drilling in 1916 and the first petroleum was produced in 1918. After legal transfer of the concession to the Tropical Oil Company in 1919 the rate of development increased. Sporadic drilling in other parts of the country during the early years produced essentially no results and many concessions were abandoned.

LAWS

The first petroleum law was enacted in 1919 and was followed by a period of great activity; about eight hundred applications for concessions on government lands were made up to 1927. Much activity was of speculative character rather than scientific, with result that all concessions and contracts, granted under the 1919 law on government lands were cancelled by an emergency law in 1927. With help of national and foreign authorities, the National Government initiated a complete study of petroleum legislation and as a result, presented to the National Congress, in 1929, a proposed petroleum code. In 1931, after much discussion and modification, Law 37, a new petroleum code, was enacted. The statue is still in force, but has been modified and augmented by subsequent statutes and decrees.

There are certain aspects of the petroleum laws which oil companies consider unfavorable to investment and exploratory work in Colombia. Their chief complaints concern the extended period of time required to establish title, short time allowed for exploitation, size of the concessions that may be applied for, delays in granting concessions while new laws are pending

FIGURE 1.—Commercial concessions in Colombia for petroleum production. Three are producing—De Mares, Barco, and Yondó; two are as yet potential—Cimitarra and El Dificil.

and requirement that all oil must be exported from Colombian ports.

Under the present law, an operator must plan on seven to twelve years after making application before his title is established and he can drill for oil. During the period he must make an accurate survey to establish boundaries and present a topographical map; furthermore he may only apply for concessions not exceeding 50,000 hectares (about 125,000 acres) and a new law now under consideration would restrict concessions to 25,000 hectares (about

62,500 acres). Exploitation time runs for thirty years, during which a company must plan to realize on its investment. Although a ten-year extension of the time may be secured, royalty agreement must be in accordance with laws in force at the time the extension is made and so may be different from that of the original thirty-year period. As a new petroleum law is now under consideration, all applications for concessions are held inactive pending the passage of the law. This has occurred previously when former laws were under consideration and has resulted in delays which the oil companies cannot avoid. The matter of moving oil out of Colombia through one of her own ports, when a foreign port is more accessible, is discussed in connection with the Barco Concession. Furthermore, if oil is found in the Llanos it will present an even more costly and difficult problem than that of the Barco Concession, as transportation to a Colombian port will necessitate moving it through a pipeline from the very low elevation of the Llanos over the crest of the Eastern Cordillera and then through the jungle and swamp country of northern Colombia to the sea. It has been estimated that it would cost from one hundred to three hundred million dollars to build such a pipeline and that production of at least two billion barrels of oil would be required to pay the cost of the line alone.

PRESENT PRODUCING REGIONS

While exploration and testing for oil has been extensive in widely scattered parts of the country, only three concessions are at present in commercial production, the Barco Concession in northeastern Colombia, in the southwestern part of the Maracaibo Basin; and the Yondó and De Mares Concessions, in the middle Magdalena River valley. At present the De Mares Concession is the leading producer, followed by the Barco and the Yondó Concessions, but the position of the De Mares Concession may not endure as it has shown some evidence of decline in production and the company is searching for new oil fields in other parts of the country.

De Mares Concession

As in so many other places in the world, oil seeps, which Quesada called "boiling fountains," led to opening a modern oil field. A traveler from the region collected samples of the gummy material which he had found oozing from the rocks and showed them to Señor Roberto De Mares. Señor De Mares realized the importance of the samples and in 1905 applied to the government for a concession to explore and exploit petroleum in the region where the seeps were located. The De Mares Concession, located in the middle Magdalena valley and including an area of approximately 1,250,000 acres, is described as beginning at the mouth of the Sogamos River and extending upstream along the eastern bank of the Magdalena to the mouth of the Carare River,

FIGURE 2.—Pipe yard at La Petrolea camp in the Barco Concession. Dense tropical growth surrounds the establishment, significant of one of the obstacles that must be overcome in validating an oil concession in Colombia. (Courtesy R. Agassio, Colombian Petroleum Company.)

then east along the Carare River upstream to the eastern Andes mountain range and north along the range to the Sogamos River and then westward downstream along the Sogamos to the starting point at its mouth. The concession is owned and operated today by the Tropical Oil Company, a subsidiary of the Standard Oil Company of New Jersey. Although the first producing well was drilled in 1918, no oil was exported until 1921. A pipeline was opened in 1926 to connect the concession with a maritime port, and exportation of oil on a commercial scale began in the same year; from that date Colombia began to play an important part in international petroleum markets.

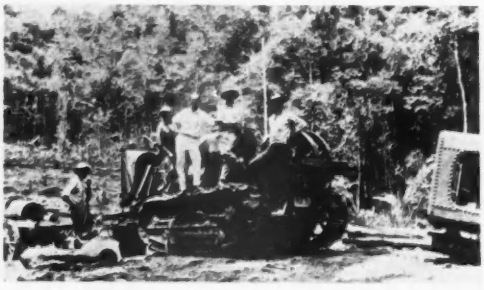

FIGURE 3.—Hauling material on the De Mares Concession, Infantas structure. Caterpillar tractors form one of the surest and strongest means of transportation power through rank tropical growth. (Courtesy of the Pan American Union.)

There are now three producing fields in the concession. The first structure developed was Las Infantas, the second, La Cira, the third and most recent development is the Galán in the north end of the concession.

The pipeline from the concession to the sea was built and is operated by the Andean National Corporation Limited. It starts at El Centro in the concession and has its tide-water terminus at Mamonal Terminal ten miles across the bay from Cartagena. Products of the company's refinery at Barrancabermeja are shipped via the Magdalena to various river ports which act as distributing centers for the interior regions.

Barco Concession

The Barco Concession is located in northeastern Colombia near the Venezuelan border, on the southwestern edge of the Maracaibo Basin, lying south of the Río de Oro and between the Catatumbo River on the east and the Cerro Bobali and Sierra de Ocaña on the west.

It is the concession obtained from the Colombian Government by General Virgilio Barco in 1905 for the purpose of exploring for, and exploiting of, petroleum. He made an unsuccessful attempt to sell it to the Standard Oil Company in 1907, but eventually did sell it to two North American oil companies, after which it changed hands several times, finally being sold to the Texas Petroleum Company and the Socony-Vacuum Oil Company, Incorporated who went into a fifty-fifty partnership to develop and operate the concession.

One of the most difficult problems of development was getting the petroleum to the sea, since the contract with the government called for the building of a pipeline to provide an exit for the oil through a Colombian maritime port. The concession lies on the eastern flank of the easternmost mountains of Colombia and faces the Maracaibo Basin. An outlet to Lake Maracaibo would have been relatively simple, but leads through foreign, not Colombian, territory, and therefore could not be used;—a case of a political boundary interfering with normal functioning of geography. Supplies could be brought in through Venezuela but oil could not be exported through that country. When the present owners purchased the concession, there were several producing wells, but no outlet for the oil, as the country between the concession and the Colom-

bian seaboard includes a variety of formidable obstacles: high mountains, dense tropical forests, swamps, numerous rivers, and the hazards of floods, malaria and other fevers, as well as the savage Motilones Indians.

Construction of the pipeline began in 1937. First a road had to be surveyed and built through the inhospitable country to the concession. The pipeline, which is 263 miles long and required six thousand men and nearly two years to build, follows the same route. The concession terminal of the pipeline is in the Petrolea field and it reaches the sea at Coveñas on the Gulf of Morrosquillo, south of Cartagena.

Supplies were either brought down the Magdalena River to Puerto Sagoc and from there flown in to the places along the road and pipeline where they were to be used or reached the concession via lake barges on Lake Maracaibo, thence by river steamer up the Catatumbo and finally by a two-foot gauge railroad to Petrolea.

The jungles, which the pipeline crosses, between Lake Maracaibo and the Magdalena River are inhabited by the Motilones Indians; the concession is also located in their territory. They are noted for their savagery, triple-barbed arrows and violent dislike of intruders. Their arrows are reputed to be poisoned but are apparently only dirty so that in some instances they infect their victims with tetanus. Several men lost their lives as result of being transfixed by Motilones' arrows, many have been wounded. The Indians continue to be one of the hazards to working in the concession and along the pipeline.

The owners of the Barco Concession were required by the Colombian Government to stake out their final claims before August 1941; the rest reverting to the government. The present concession, therefore, comprises 460,000 acres and is still mainly in the exploratory stage so far as testing all promising structures. At the end of 1945, there were four producing fields: Petrolea, Carbonera, Río de Oro and Tibu. The Petrolea structure, first to be drilled, has not fulfilled early optimistic expectations, although it produced more oil per day in 1945 than any other field in the concession. Río de Oro lies in the worst Motilones country and has no pipeline outlet as yet. Carbonera is a small field, having only three producing

FIGURE 4.—General view of La Petrolea camp, Barco Concession. Modern comfortable buildings, planned and built to insure optimum living conditions for the workers, have made a great change in the labor capacity of the employees. (Courtesy R. Agassio, Colombian Petroleum Company.)

wells in 1945. Tibu, a recently developed structure, whose first oil reached Coveñas in 1944, is expected to become an important producer.

Petroleum from the Tibu Concession is a green-gold color rather than the more usual black, and yields as high as 49 per cent gasoline on straight-run refining. Its superior quality is reflected in a higher market price as shown in 1943 when the average price per barrel of oil from the Barco Concession was $1.50 in contrast to an average of only $1.00 per barrel for crude from the De Mares Concession. The higher value is significant since unfavorable geographic conditions have made development of the field particularly costly. Distance from the sea, nature of intervening terrain, and probable quantity and quality of the petroleum are all factors that have had to be considered in determining the economic feasibility of developing Colombian oil fields. High quality crude is an important factor in offsetting greater developmental cost in regions which are especially inaccessible.

Resources of the upper Catatumbo Basin have just begun to be tapped. How much oil there is in the region remains to be determined after further exploratory work and testing. The Colombian Petroleum Company is the producing company for the concession and the South American Gulf Oil Company built and operates the pipeline, both companies being owned in joint partnership of the Texas Petroleum Company and the Socony-Vacuum Oil Company.

Yondó Concession

The Yondó Concession, owned by the Shell Oil Company (Compañia de Petroleos Shell de Colombia), comprises 115,000 acres, 180 miles north-northwest of Bogotá on the west bank of the Magdalena, just across the river from the north end of the De Mares Concession.

The Casabe field is the producing area. The first well was completed in late 1941, but no oil was shipped until a branch pipeline was completed in 1945. The pipeline connections from the field were made via a six-mile branch line to Galán station of the Andean pipeline, which connects El Centro in the De Mares Concession with Mamonal Terminal. Equipment and supplies can be brought down the Magdalena by river boat thus saving expense of overland transportation. Road construction is costly, the surrounding territory and even much of the concession itself is swampy and so subject to floods that dikes have had to be built along the river to protect the oil field. It is a fast growing field; there were 29 producing wells in 1945 and the crude from Casabe accounted for a substantial increase in Colombian output.

FIGURE 5.—Infantas well No. 1, De Mares Concession. How difficult it is to bring in a producing well under tropical conditions can be imagined from seeing only a picture of the equatorial rain forest. (Courtesy of the Pan American Union.)

FIELDS NOT YET IN COMMERCIAL PRODUCTION

There are, at the present time, only 29 concessions actually in force in

Colombia, three of which account for all of the petroleum output of the country and which have been discussed in the preceding section of this paper. Oil has been found in two other concessions but they have no outlets and so are not yet in commercial production.

The two new oil fields recently discovered are in the El Difícil Concession of the Compañia de Petroleos Shell de Colombia (a Shell Oil Company subsidiary) in the lower Magdalena valley and in the Cimitarra Concession, Cantagallo field, of the Socony-Vacuum Oil Company, in the middle Magdalena valley. Although production in El Difícil began in 1943, no pipeline has been constructed to the concession because of its inaccessibility. It is 90 miles by road from the field to El Banco on the Magdalena and then 180 miles downstream to Barranquilla. The Cantagallo field 15 miles north of the Casabe field on the west bank of the Magdalena, is believed to extend into the river bed and beyond to the east side of the river where the company also has concessions. Logical outlet for this field will be via the Andean pipeline where it crosses that part of the concession located on the east bank of the river.

Effect of the War on the Oil Industry

During the early stages of the war procuring equipment and experienced workers was difficult. As a result all progress was slowed down generally, as evidenced by decrease in the number of new wells drilled. Production of oil was also seriously affected by lack of shipping facilities. However, during the latter part of the war Colombian output was accelerated to supplement petroleum supplied to the Pacific theatre. Pipelines, the so-called "Double Pipeline," of which the existence was recently revealed by the Navy, were constructed during the war across the Canal Zone to facilitate transportation of oil to the Pacific. Colombia's proximity to the Pacific theatre, via the Canal Zone pipelines, and to refineries on the Dutch islands of Aruba and Curacao made her position strategic for supplying petroleum and petroleum products to the Pacific.

The war impressed the importance of petroleum very forcibly on the governments and people of all of the South American countries with the result that their interest has been greatly stimulated and exploratory activity is now increasing. In Colombia alone, in 1944, new capital imports into the country by the petroleum industry amounted to $20,000,000.

Value of the Petroleum Industry to Colombia

Petroleum is Colombia's second largest export (coffee is first), accounting for about 25 per cent of her total export values. In 1944, Colombia supplied 7 per cent of all the oil produced in Latin America, exceeded only by Venezuela with 62 per cent and Mexico with 12 per cent.

TABLE 1

PETROLEUM PRODUCTION IN COLOMBIA

CRUDE PRODUCED

(000 barrels 42 U. S. gallons)

Year	*Amount*	*Year*	*Amount*
1921	67	1934	17,341
1922	323	1935	17,598
1923	425	1936	18,756
1924	445	1937	20,599
1925	1,007	1938	21,582
1926	6,444	1939	23,857
1927	15,014	1940	25,593
1928	19,897	1941	24,553
1929	20,385	1942	10,590
1930	20,346	1943	13,261
1931	18,237	1944	22,647
1932	16,414	*1945 est.	25,100
1933	13,158	.....	.....

*Estimates for 1945 range from 22 to 28 million barrels.

Production of petroleum in Colombia has also tremendously increased her

domestic demand for refined products. In 1920, Colombia's needs were met by 63,790 barrels of imported crude; in 1929, 1,784,067 barrels of her own oil were required and in 1938, 2,762,343 barrels of crude were refined in the country. Colombia has about 15,000 miles of roads, some of which are partially paved, all-weather roads and, since there are only some 2,000 miles of railroads which are particularly costly to build, she has, like many other countries, found it less expensive to build highways for trucks and other motor vehicles. They are increasing in number and using more and more Colombian refined gasoline and lubricating oil. A dense network of air routes covers the country and some of her crude can be used for producing aviation fuel which thus finds a ready market at home.

FIGURE 6.—Pulling pipe by means of pontoons across El Dique near Cartagena for the pipeline from the De Mares Concession to Mamonal Terminal. By overcoming the many natural difficulties imposed by terrain and vegetation, the concession has been made to conform to Colombian requirements. (Courtesy of the Pan American Union.)

Residues from refining processes supply material for constructing all-weather surfaces on her roads.

The petroleum industry makes an important contribution to the income of the National Government. Colombian royalties amount to about 10 per cent of the crude, plus taxes, surface rents, and free use of the pipelines for a certain number of hours each month to transport government owned oil and refined products. Revenues paid to the government amounted to about $6,000,000 or nearly 14 per cent of its total income in 1942, a year in which acute shortage of tanker transportation caused serious curtailment of production, from over 24 million barrels in 1941 to only little more than 10 million barrels in 1942. Although comparable statistics are not available for other years, it is reasonable to suppose that in years of greater petroleum production, percentage of the government's total income; yielded by the oil industry, must be more than 14 per cent. The above figure is classed as direct revenue and does not include salaries and wages paid to employees and other expenditures by oil companies within the country.

Colombia has benefited in other ways. Employment has been given to some of her nationals, standards of living have been improved for workers and their families, employees' homes have been built, sanitation and rural hygiene have been introduced. Medical and hospital facilities, education and industrial training have been provided. In considering these things it should be recalled, however, that the number of workers in the petroleum fields is estimated to be only about 5,000 to 10,000 so that relatively only few persons have profited by the improvements. Future development of the industry will require more workers but percentage of total population employed will probably always be rather small. Churches, schools and post offices have also been built by the oil companies. Isolated and jungle covered country has been opened, roads, air fields, railroads and ports built. But again only a small portion of the country has been affected by the changes.

Some Colombians resent bitterly the alienation of their country's natural resources, which they say may be exhausted in a few years so that future

generations will have to import oil and will, therefore, criticize the present generation for allowing such a valuable natural resource to be piped out of the country to be utilized in other parts of the world. Another viewpoint with reference to the problem should also be considered. It is a question when Colombia might be able to explore and exploit her own oil lands without outside help such as capital, civil and petroleum engineers, geologists and other technicians. It is also possible that in the future when Colombia's oil is gone, new sources of power will have been discovered to supplant or at least materially supplement oil. By pursuing a restrictive policy, Colombia might at some future date find herself possessing oil of which value had decreased due to competition of other sources of fuel.

Large quantities of more cheaply marketed petroleum in some other part of the world may also offer serious competition. There is evidence in Venezuela, where politicians are already concerned about their future markets for petroleum, that such contingency is possible. Recent intensified interest in the oil fields of the Middle East, particularly those of Arabia, plus possibility of a pipeline from the Arabian fields to the eastern end of the Mediterranean, may provide European markets with cheaper oil than that from northern South America. What would apply to the markets for Venezuelan oil would apply equally to those of Colombia, since, aside from the United States, Canada and Argentina, Colombia's principal petroleum markets are in Europe, notably Italy, France, England, Belgium and Germany.

Colombia is considered to be one of the more progressive and most democratic countries of South America, having achieved national coherence in spite of great diversity of terrain, climates and people; but she still has many handicaps to overcome before her many social and economic problems approach solution. Inadequate transportation and remote regions outside effective territory of the country are two important obstacles to future development. Due to unsatisfactory or entire lack of transportation, pipelines had to be built to her ports before any appreciable

FIGURE 7.—Pipeline being laid through the forest. Laying pipeline through the equatorial forest, with weather characterized by high heat and humidity, and productive of numerous pests and diseases, offers difficulties and hazards unknown in temperate fields. (Courtesy of the Pan American Union.)

amount of petroleum could be exported. None of the present petroleum-producing concessions are located in sections of the country that can be economically served by transportation facilities, other than pipelines, for carrying petroleum. Even concessions in the Magdalena valley have not been able to depend upon the river, although it is Colombia's chief artery of transportation. The Magdalena is very untrustworthy and inefficient during the dry season when its water is shallow, and numerous sand bars, and rapids along portions of its course make navigation precarious.

Transportation difficulties of the oil companies have emphasized the backward state of Colombia's communications. Colombian railroads are largely oriented toward the Magdalena, so that a combination of railroad and waterway is used, causing expensive bulk-breaking for freight shipments and many delays, and increasing freight rates, a serious handicap to internal development of the country. More adequate rail service, independent of the river, plus more highways for trucks and other motor vehicles would be a boon to Colombia.

Not only is it difficult to reach the oil fields but also the areas of major population concentration. Aside from the north coastal region, most of the people live in isolated valleys and basins in Colombia's three great Cordilleras, widely separated from each other. To provide communications among the scattered clusters of people and to connect them with the coast is very costly, due to the intervening mountains, swamp and forest-covered lands. For passengers and valuable cargoes, the airplane has solved many of the difficulties of transportation, one of the oldest commercial air lines in the Americas being located here, evidence of need for more efficient transportation. Remote areas remain to be opened by air transport, but air fields and other facilities must be provided before it can be done.

Colombia also needs more schools, especially vocational and agricultural, for her rural population, in order to raise their standard of living and increase efficiency of their agriculture, which in many of the remoter parts of the country and in some not so remote is merely subsistence type. Improved agriculture and added income would increase purchasing power of the people and provide markets for Colombian manufactures which in turn would aid in development of industry and employ more of Colombia's people on a higher wage scale.

Some essential requirements could be financed, at least in part, by government revenues from petroleum. The oil industry has already set the example in its programs of social and economic betterment for its workers and in its development of more adequate transportation for its own products and essential supplies. If the petroleum royalties, now being paid to the government, can aid in the present development of Colombia, they may contribute more to the country's welfare in the long run, than keeping the oil in the ground until such time as Colombia herself can exploit it.

ECONOMIC DEVELOPMENT OF THE GREAT KANAWHA VALLEY

Leslie Martz Davis

GROWTH of chemical manufacturing and mining activities of the Great Kanawha Valley of central West Virginia has been an outstanding economic achievement of the past quarter century in the eastern portion of the United States. The development has been determined by use of mineral resources of the valley, since local brines, bituminous coal deposits, oil pools, and natural gas pockets, influence directly or indirectly economic pursuits of the region. Use of such resources has necessitated construction of railway, river, and highway facilities to handle coal shipments, building of pipe lines to carry away oil and gas, erection of electric installations to furnish power along the valley, and building of numerous chemical plants to process materials for nation-wide industrial markets. Lumbering has contributed to mining through supply of mine timbers and railroad ties for coal carriage, as well as to such non-mining uses as general construction work and fuel for house heating. Agriculture along the eighty-nine mile valley which operates mainly to supply foodstuffs and feeds to mining and industrial centers of the upper and middle valley, is handicapped in operation by the relatively small area of fertile soils available for tillage. Local commerce is focused on Charleston and likewise is directed to serve mining and industrial demands.

The Great Kanawha River Valley, hereafter referred to as the Kanawha Valley in accordance with local custom, is located in the western central part of West Virginia, and includes the counties of Fayette, Kanawha, Putnam, and Mason. (See Figure 1.) Its location facing the Ohio Valley is doubtless responsible for allocation of a portion of its outgoing manufactured goods shipments to such urban centers as Cincinnati, Columbus, Pittsburgh, and Cleveland, rather than to the eastward Allegheny Plateau, Valley of Virginia, and the Blue Ridge, where there are but few small city markets.

FIGURE 1.—The solid line drawn through the four shaded counties of West Virginia marks the course of the Great Kanawha River.

SURVEY OF ECONOMIC DEVELOPMENT

Pioneer movement into the region at the western edge of the highly dissected Allegheny Plateau was slow in comparison with flow of settlers through the Mohawk-Genesee plain to the north and Cumberland Gap to the south, since the deep gorge of New River canyon to the southeast of the Great Kanawha (hereafter called the Kanawha) checked immigrant wagon transportation. Land transfers from the Federal Government

moved slowly until after the War of the Revolution, although surveys had been made along the lower river in 1770 by George Washington and other Virginia engineers. The first activity of importance was the pumping of brine near Malden in 1785; by 1806 drillings for stronger brine had reached a depth of 400 feet according to Lorena A. Anderson, *Salt Industry of the Kanawha Valley*, a master's thesis at Marshall College, Huntington, W. Va., 1942, pp. 13, 17, and 21. Coal was used as fuel at certain salt works by the later date, and natural gas was struck in a brine bore in 1815. Oil was found in some drillings and was channeled into the river where it might escape and not interfere with salt operations. In 1841 a flow of gas from a salt boring was used in boiling brine. Rafts or canoes were used by 1808 in transporting salt, flat boats were employed shortly after, and steamboat movement came in 1824. Coal was being mined along the Kanawha, Coal, and Elk rivers during the sixties. Farming and timber cutting grew in importance throughout the period, with peak forest operations reached in 1916.

Major economic development came slowly in the valley, due mainly to the fact that rail and highway building were developed by degrees. The highway west from Charleston to the Big Sandy was projected in the 1830's, but the road carried little traffic for a number of years. Consolidation of rail lines into the Chesapeake and Ohio system opened the way for rail service between Charleston and the Ohio River by 1873. Industries developed gradually in the upper and middle valley, but the period following World War I was characterized by the great impetus in chemical plant location which set the pattern for valley industry. Scattered chemical manufacturing units were built from the confluence of the Gauley and New rivers fifty miles downstream, and the valley landscape changed to its present appearance, with industries located in or near numerous small towns straggling along lower hillsides in shoestring pattern down the narrow, winding valley. Charleston grew rapidly, as many families moved from tributary valley settlements or farms to the urban center where work was available to unskilled laborers.

TRANSPORTATION FACILITIES

Highway and railway routes tend to parallel the river closely through the valley or to cross the river at Charleston or Point Pleasant, with few units crossing the valley at other points. Convergence of routes on Charleston has helped the city industrially and commercially, but transportation funneling through Point Pleasant has not helped population growth as much as might be expected, probably because of the buffer location between Charleston and Huntington. Valley transportation exists in terms of use of river, railways, highways, and airways, with the last named units of minor importance at present.

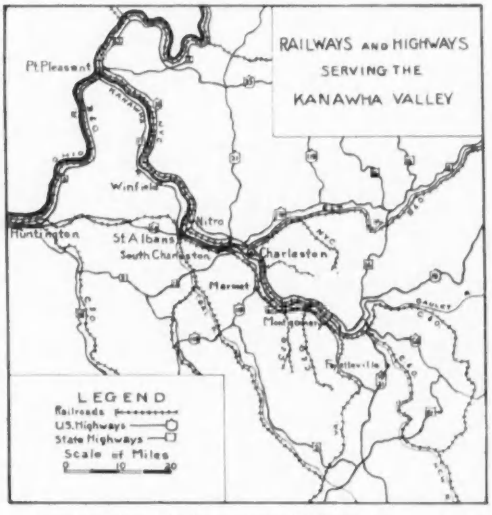

FIGURE 2.—Railways and Highways serving the Kanawha Valley.

Navigation on the Kanawha River was important in early days of settlement, but following building of railways and highways river traffic has been of little importance except for movement of logs, coal, sand, and gravel. Rafts of logs were floated down the Kanawha and its main tributaries in the formative period of valley economy, but that activity has been a matter of history the past two or three decades. Coal shipments are made downstream in barges, with a portion of the coal secured from hillside outcrops and loaded into the barges by gravity methods. Sand and gravel movements also are made through the nine-foot river stages except during the 12.3 day average period yearly when ice conditions close the river to traffic. Bulk oil shipments might be made downstream by tank barges from the Cabin Creek district a few miles east of Charleston, but railroad and pipe-line competition will likely prevent development of that phase of river traffic. Transportation on the Kanawha has potentialities but little possibility of marked development in the near future. Adequate rail and highway freight carrying facilities have supplanted need for low-speed river barge carriage of bulk materials, and it is doubtful that there will be an increased demand for low-cost water transportation as long as speed in carriage is likely to be the major determinant instead of cost per ton mile in freight movement.

Railway facilities in and near the valley were designed primarily for movement of bituminous coal, and traffic is largely an east-west movement of loaded or empty coal cars, with a minor traffic stream flowing north-south mainly on rail spur lines. The Chesapeake and Ohio system dominates the local rail traffic pattern with its Washington-Norfolk to Cincinnati-Louisville main line leading through the valley above St. Albans, double track facilities serving throughout the year the numerous long trains made up mainly of coal-carrying cars. (See Figure 2.) The company also has a number of spur lines running up valleys to coal fields in this part of the state. The Kanawha Division of the New York Central serves the northern side of the valley through Point Pleasant, connecting with the Virginian near Gauley Bridge on the upper river. The Baltimore and Ohio has a line running north from Charleston up the Elk River Valley.

The highway net of the valley differs from the railway pattern, in that certain highways cross the river, rather than run parallel to it. A number of federal and state highways are built through central West Virginia, and several secondary roads are available between arterial highways. Highway U. S. 60 crosses the state between Huntington on the west and White Sulphur Springs on the southeast, running along the north side of the valley between Gauley Bridge and Charleston, where it crosses to the south bank and follows the Kanawha to St. Albans. U. S. 35 serves the north bank between Charleston and Point Pleasant, while U. S. 119 from the south passes through Charleston and northeast up the Elk River Valley. The remaining federal highway, U. S. 21, serves Charleston and Parkersburg. A number of state highways having varying gradient conditions radiate from Charleston and Point Pleasant, serving the valley and tributary service areas. Valley highway transportational activities center mainly on Charleston, and are largely coal hauling, industrial unit service, multi-type commercial hauling based on Charleston wholesaling and jobbing activities, and movement of agricultural produce into and along the valley. Charleston is the regional center

for Greyhound bus service and has city bus service which reaches out into hill suburban sections. Private motor car operators of the upper and middle valley consider Charleston their trading center, while lower valley motor traffic is divided between Charleston and Point Pleasant. The latter city is a motor trucking center, due mainly to activities of a commercial trucking company which serves an area reaching into central Ohio and southern Pennsylvania.

Air transportation in the region is undeveloped and must be discussed in terms of probable future operation. Service has been given both Huntington and Charleston on a Cincinnati-Washington major air line, but unsatisfactory field facilities have hindered traffic development. Charleston is now building a field large enough to satisfy operational demands, and Huntington doubtless will secure similar facilities. Crowded valley conditions near Charleston forced the selection of a hilltop site a few miles from the city. Grading difficulties and highway approach building problems are major items in the development, emphasizing handicaps experienced in air field construction in a hill country. The carriage of passengers offers the major challenge in local air service expansion, since it is doubtful that plane freight carriage will be important in competition with services of rail, river, and highway service units.

FOREST ACTIVITIES

Lumbering started early in the economic development of the valley and intensive cutting had depleted good commercial timber stocks by 1925. Hillsides and valleys were almost covered originally with stands of walnut, cherry, oak, poplar, hickory, maple, elm, and ash, since rainfall conditions and relatively short winters favor tree growth. Heavy cutting started around 1860 at the time of industrial expansion in the Ohio Valley and the eastern portion of the Corn Belt.

Lumbering in the valley following 1860 was dependent on markets and was restricted by transportation facilities. River movement of log rafts came with market calls from Ohio River points, and floats down the Elk, Kanawha, and Coal rivers to Point Pleasant accounted for early movement of a great forest crop which experienced raubwirtschaft operations of serious proportions. Barrel and pipe staves, ship timber, car stock, tan bark building materials, and railroad cross ties, were furnished in increasing quantities until portable sawmill operators were forced to begin working previously considered marginal timbers. The local salt industry purchased large quantities of barrel staves until the Ohio Valley industry curtailed the Malden activities. Black walnut logs were carried out by barge and rail car, many oak and poplar logs went to ship timber markets up to 1900, and staves were shipped by one manufacturer to a number of European buyers.

Lumbering in and near the valley has been declining in importance the past two decades, although demand remains heavy in the region. During World War II the emergency call for pulpwood increased the cutting of even small trees to help fill the unprecedented demand. Local industries needing wood, as for example oak for the Huntington car works and railroad cross ties, have depended in part on local supplies, but increasingly lumber must be brought in by rail to supply industrial and building needs. Many hillsides have stands of trees, but better woods are difficult to find, and such trees are frequently cut too soon to make good logs. Forest cutting will continue in the region but

lumber output tends to decline, and quality of the lumber to deteriorate.

COMMERCIAL AND SERVICE ACTIVITIES

Commercial activities in the valley are classed under the general headings of wholesaling and retailing, and a summary treatment of the two levels of distributive service helps strengthen the picture of the Charleston metropolitan influence on the economic life of the region. Service activities other than sale of goods to consumers are more difficult to check in method of operation and areal spread, and they are quite important in settlement centers throughout the valley.

Intensive wholesale and jobbing coverage of the valley and nearby sections of the state results from activities of the Charleston units in reaching what they consider their field of service. A degree of competition is offered in this service area by wholesalers and jobbers of Huntington and other cities within a two hundred mile radius, but to a great extent selling to retailers is done by Charleston units, especially in foodstuffs, dry goods, drugs, and hardware lines. Wholesale sales volume in Kanawha County alone reached the sixty million dollar level in 1943. (Figures were taken from *Kanawha Commerce*, published by Chamber of Commerce, Charleston, W. Va., January, 1944; vol. 7, no. 1, p. 3.) Charleston and South Charleston contain numerous retail outlets receiving frequent wholesale delivery service, and it is difficult for wholesalers of other cities to break into the important urban market. Retail outlets in smaller centers spaced along both sides of the Kanawha and in scattered towns and villages throughout remaining areas of the four counties are given efficient delivery service, and relatively little competition is experienced down river by Charleston wholesalers and jobbers until Huntington selling is met above Point Pleasant. Wholesale service in the valley and nearby hinterland sections, therefore, is largely under control of Charleston. Activities in other towns likely vary with town size.

The pattern of retail outlets in the region follows closely enumeration of cities and towns shown in Figure 3. The bulk of retail selling is done in the Charleston city district, smaller sales being made in each of the pendant satellite communities and small trading centers not shown on the map. Charleston and South Charleston each has a downtown grouping of retail and service units, and Charleston has (1) string

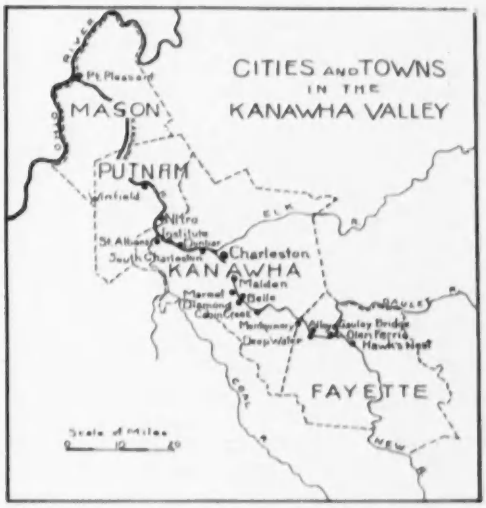

FIGURE 3.—Cities and towns in the Kanawha Valley.

street type units straggling along main traffic streets away from the downtown shopping district, (2) practically self-contained community centers nearer the city outskirts, and (3) scattered oil station or grocery types so common to the American urban scene.

Remaining consumer serving units of the region have areas differing widely in extent, depending on type of activity, effort displayed in reaching consumer

groups, distance to nearest competitors, and type of highway reaching out from the unit. The last item is quite important, since better roads tend to throw consumer buying toward favored centers, although units such as rural church bodies and established grocery and general stores resist the centripetal action. Movement toward community center rather than cross roads schools has followed the state trend, and carrying of elementary and secondary school children has been accelerated in the four county area. Banking units draw patronage roughly as far as the outer service area of competing banks, but newspaper circulation follows county lines more closely due to emphasis placed on county news—although an exception may be made for the two Charleston publications which reach out over the central portion of the state. Units such as barber shops and beauty parlors depend largely on trade coming from the town center, and draw comparatively little business from surrounding rural districts.

TABLE I

POPULATION FIGURES FOR 1940
TOWN LOCATIONS ARE SHOWN IN FIGURE 3

Charleston City	67,914	South Charleston	10,377
Dunbar	5,266	Nitro	2,983
Marmet	1,814	St. Albans	3,558

(United States Census, Bureau of the Census, Department of Commerce, Washington, D. C., 1940, population of West Virginia, first series, table VII.)

VALLEY AGRICULTURE

Agriculture in the Kanawha Valley and on the adjacent hillsides and valley bottoms and hillsides of tributary streams is of less importance than agriculture in similar size areas of the richer soil Corn Belt to the northwest or Cotton Belt to the south, and also is of secondary importance in the upper and middle valley in comparison with mining operations and chemical manufacturing. Farming along the valley is both general and special type, but recent developments point to specialization of agriculture in direction of furnishing foodstuffs and feeds for local needs, with little thought directed to sales outside the region. Truck gardening for the Charleston–South Charleston market is assuming greater importance. Dairying as a distinct field is being strengthened as valley and other nearby farmers realize importance of a year round cash crop with steady market. Growing of feeds for sale to dairy herds and other farm animals is important especially in the lower valley, where the widening plain offers more land for crop growing.

Emphasis varies on agriculture in the counties, although number of farm workers in Kanawha and Putnam counties in 1939 was almost identical, with Mason County having a larger number. Emphasis on coal mining in Fayette County, and on coal mining and industry in Kanawha County, is much greater than that on farming for the two counties. Cropland reported for the four counties varies, since in 1939 Fayette County had 421,760 acres of land with only 21,783 cropland harvested acres reported, Kanawha County had 581,120 acres and 25,087, respectively, Putnam County 223,360 and 28,226, and Mason County had 45,794 acres in cropland harvested reported of its 276,480 acres.

Truck gardening activities are developing as city markets in Charleston and South Charleston take greater quantities of fruit and vegetables. Commercial apple orchards are found in Mason and Kanawha counties and in some other parts of the valley, local markets being created early for the highly desired fruit which withstands frost hazards better than some local fruits. Mason County growers ship

to Ohio and Pennsylvania by truck and rail to dispose of the yield not sold to buyers coming to the orchards or to buyers found in nearby cities who are reached both through farmer markets and by house-to-house distribution according to Mr. Walden Roush of Point Pleasant who supplied much of the information used relative to agriculture in the lower valley. Small orchards of peach, cherry, or pear trees grow throughout the valley, but usually the number of trees in each orchard is so small that the crop surviving frosts will likely be used by the grower or sold in the immediate community. Grapes are found in Fayette County and hilly sections of Kanawha County, but are not grown commercially elsewhere. Vegetable growing is mainly in white potato, tomato, sweet corn, and green bean acreage. Home gardens and farm vegetable acreage are usually small because of the labor problem and difficulty of reaching markets.

Field crops along the Kanawha Valley are mainly grains, with hay and tobacco ranking high in sections of the region. Grains are largely corn, winter wheat, oats, and barley, with corn and winter wheat high in acreage. Corn is grown in fairly large patches all through the valley, and small size fields are common on slopes and uplands as in other sections of Appalachia, adding to the dangers of soil wash and causing a serious problem in soil conservation. Corn is grown for local cattle and hog feeding, and only small amounts are carried to outside markets. Hybrid varieties are being introduced, and established types are planted at different elevations, especially in Mason County where dairying interests are especially concerned with production. Winter wheat acreage is less than that of corn, and quantities of harvested grain are mixed with corn for dairy feed, providing local market. Oats acreage is low, probably due to the small local demand for the grain for horse and mule feed. Hay growing is outstanding in the

FIGURE 4.—The downtown section of Charleston lying east of the Elk River and its confluence point with the Kanawha. Industrial and commercial demands for space in the narrow valleys cause residence planners to seek hillside and hilltop sites for homes.

dairying sections of the valley, but is not stressed elsewhere, Mason County having a relatively high acreage of clover and timothy, and growing alfalfa and soy bean hay for dairies. Tobacco is important only in the western part of the region, where the crop is grown on both bottom and hill lands, with air-cured leaf marketed mainly in Huntington.

Growing of work animals is unimportant, and the cattle, hogs, and sheep, produced for the packer and home slaughter markets are relatively few in number. Work animals are surprisingly scarce, since Fayette, Kanawha, and Putnam counties grow few horses and mules, and only Mason County ranks fairly high in producing these animals, as is the case also in production of meat animals. Beef fattening for regional markets is a small scale activity, with pasture fattened animals sold in autumn and corn fed beef cattle held over for winter sale. Local auction markets are held at Point Pleasant, with some Mason County stock carried to Huntington, Charleston, or Chillicothe, Ohio. Hogs are grown in all parts of the region, some for early winter killing for local family unit consumption and others for slaughter in nearby city packing houses. A number of dairy farmers in the lower valley raise hogs as scavengers, and most such swine are killed for local consumption. Sheep are grown mainly in Mason County, although little attention is given to them they might thrive in this region having such great area of slope grassland.

Dairying efforts are increasing as Charleston and the smaller centers buy more milk, butter, and cream. The Charleston milk shed reaches down the valley to Point Pleasant and then north a few miles up the Ohio Valley (the Ohio Valley south of Point Pleasant sends to Huntington), up the New River Valley, and north and south of the Kanawha Valley for thirty or forty miles. The producing area near Charleston has the advantage of being nearer the major market, but the lower Kanawha Valley has larger areas of relatively level land for dairying operations. Many larger dairies in Mason County have modern equipment and high production cows, in marked contrast to poorer equipment and lower production animals found in many hill sections. Mason County runs high in milk sales but does not promote butter production; it makes cream sales to agencies from nearby cities and even as far distant as Columbus, Ohio. Dairymen along the Kanawha and back from the valley sell milk daily, in many cases to private truckers who charge for transportation by the number of cans handled.

EXTRACTIVE ACTIVITIES

The extractive activities of the valley are divided into major and minor groups, according to the number of workers involved and the monetary measure of the output. Coal mining and oil and gas extraction rank high in economic endeavour, brine production was important a number of years ago, and quarrying clays, gravel, and sand is of minor importance.

Mining of bituminous coal has been a major activity in the valley since around 1900, and more recently increasing local demands have supplemented rail, highway, and river shipments to markets in the Corn Belt and lake cities to the northwest and to ports of the east and the industrial sections to the northeast. Fayette and Kanawha counties stress mining activities, but Putnam and Mason counties have smaller coal reserves and give relatively little atten-

tion to such work. The entire area is located in the deepest part of the great geo-syncline or Appalachian basin which passes through the state from southwestern Pennsylvania to the Big Sandy country of southwestern West Virginia, and the important "Pittsburgh" coal in the Kanawha region lies at a general elevation of 800 feet above tide. Seams of workable thickness are found in varying number in different parts of the valley, with numerous seams in the upper valley, some of which are too thin for present-day mining operations.

Coal production figures and mining methods vary within the region according to conditions experienced in working various seams. Production in the four counties in 1943 was reported as follows:

TABLE II

County	*Production from Commercial Mines Reporting Tons*	*Production from Domestic Mines Tons*	*Used in Coke Ovens Tons*	*Used Locally and Stocked Tons*
Fayette	13,624,315	17,169	327,355	493,595
Kanawha	8,686,872	41,170	No report	245,423
Mason	150,640	10,018	None	10,480
Putnam	38,465	13,445	None	13,445

FIGURE 5.—Industrial plants and residential subdivisions occupy the valley at Kanawha City, east of Charleston. Encroaching hills force a shoe-string settlement pattern along the valley.

Variations in mining methods depend on the size of the operation, available transportation from the tipple, and the purpose in working the mine. Commercial mines try to follow horizontal drifts having entries above the transportational unit shipping the coal from the mine, since the gravity method of loading is economical whenever it can be used. Cutting machinery is employed in a number of operations, and in such units output per man employed is relatively high. Other commercial mines utilize manpower relatively efficiently, and it is difficult to estimate the amount of mechanization that will be used in the near future. Domestic mines produce tonnage varying per county, as shown in the table above, and operations are likely to be small-scale with irregular production. A hillside opening operated by one man or a small group of neighborhood men may be used to furnish coal for local household purposes, or to truckers who create their own markets. Employment in coal mining varies by county, as shown by the following figures:

Fayette County	11,146
Kanawha County	6,444
Mason County	150
Putnam County	147

Coal is moved from the valley by means of railroad cars, motor trucks, and river barges. Rail shipments are made in different directions, but the major shipment axis is northwest and east. The main line of the Chesapeake and Ohio, the New York Central branch down the valley, the Baltimore and Ohio services from the valley, and the Virginian to the southeast, all provide rail coal-carrying service. Motor trucking is of local importance from domestic mines, with hauls to other types of transportation or to regional markets. River barge hauling has been featured on the Kanawha and Ohio for many years, but speedier rail competition limits expansion of the potentially important inland waterway trade.

Coal reserves for the upper valley are great enough to permit present scale operations to continue many decades. State mine figures estimating original tonnage and tonnage removed show the following figures in Table III.

Natural gas production has developed rapidly in Kanawha County in recent years, and it is conjectural how long gas may be relied on as major fuel for home heating, glass making, and use in numerous chemical manufacturing plants of the valley. Production has been spotty in Appalachia for several years, with half the amount coming from West Virginia, and with the Kanawha-Jackson field supplying more than half the state production. Yield from local deep Oriskany sands is declining and recently greater dependence was placed on shallow wells. Oil is found in most parts of the natural gas field, and there are a number of pumping centers in Kanawha County. Refining operations at Cabin Creek on the upper Kanawha and on Elk River are of outstanding importance.

TABLE III

County	*Estimated Original Coal 1 Inch to 2 Feet 11 Inches in Thickness*	*Estimated Original Coal 3 Feet and Over in Thickness*	*Tonnage Removed 1883 to 12–31–43*
Fayette	1,251,489,252	3,169,015,787	477,288,240
Kanawha	803,161,766	5,098,162,846	265,267,277
Mason	No figures	339,976,480	6,666,768
Putnam	No figures	433,000,336	20,198,153
Probable recovery for the state	25%	70%	.....

Early production of salt brines was limited to the Malden district above Charleston, but later spread to the Ohio Valley north of Point Pleasant, as mentioned above. Production at Malden has declined to 150 to 180 barrels of salt a month, but by-products have increased with the making of bromine, bromides, calcium, magnesium, chloride, and salt brick.

Sand and gravel may be obtained at numerous points along the major valley and tributary stream valleys, but demand varies in accordance with building needs. Clays are secured from a number of deposits, but market demands are small locally.

INDUSTRY IN THE VALLEY

The chemical industry of the valley is the outstanding manufactural activity and accounts for the bulk of both plant production and labor employment in the upper and middle valley. Chemical plants are spaced along the river valley at irregular intervals for more than half the length of the river, reaching from the Gauley Bridge neighborhood to the Nitro locale. A few plants making items other than chemicals are located in or near Charleston, but they also depend on the low price natural gas or coal fuels which brought the chemical industry to this section of West Virginia. The numerous industrial plants are nearly all located on river terraces of varying widths and must share the narrow plain with scattered residential sites, agricultural "bottom" lands, highways, and railways.

Close relationship between fuels, brines, adequate transportation, and

FIGURE 6.—Chemical plants in South Charleston paralleling highway U. S. 60 and the Chesapeake and Ohio Railway main line and freight siding installations. The chemical properties on the island are connected with the south bank plants by means of bridges.

local chemical development cannot be overstated. Nearby deposits of high grade bituminous coal and cheap natural gas and oil served to bring a number of chemical plants to the valley. Brine pumping is a sustained activity at both Malden and north of Point Pleasant, as mentioned earlier, and supplies a basic material for certain chemical plants. Transportation on river, railway, and highway developed before the industrial pattern was filled in, and accelerated the grouping which has now become one of the great chemical activity centers of the nation.

Listing of industrial units downstream from the Gauley Bridge neighborhood shows dependence of the plants on nearness to power, raw materials, and transportation facilities. Rail transportation is furnished on both sides of the Kanawha River, as mentioned in the section dealing with transportation. The hydro-electric development of the Carbide and Carbon subsidiary at Hawks Nest, above Gauley Bridge, required the cutting of a three mile tunnel through a mountain to carry water from New River to the power plant. Electricity is carried down river, and electric furnace plants at Glen Ferris and Alloy manufacture ferro-chrome, ferro-manganese, and ferro-silicon, among other products. (The greater portion of the material used in this section on industry has been taken from a paper titled "The Chemical Industry of the Great Kanawha Valley" by J. N. Compton and E. T. Crawford, Jr., published by the American Institute of Chemical Engineers, vol. 34, no. 3, June 25, 1938.) Coal for the steam power installation at Alloy is taken from measures two miles back in the hills and brought by gravity bucket conveyors to the plant. Downstream coal mines and beehive coke ovens stand out in the landscape. A modern by-product coke oven installation has been built to retain gases lost through the older method of coke making. Cabin Creek, across the Kanawha, has a large power generating plant and oil refinery, as well as a natural gas compressor located nearby. A plant at Diamond separates hydrocarbons from natural gas for use in the South Charleston Carbide and Carbon plant.

The electrolytic plant of the Belle Alkali Company, twelve miles above Charleston, makes ammonia for E. I. duPont de Nemours and Company. (This development is made possible by a valley width permitting the erection of a large plant at this point.) This unit turns out synthetic methanol, isobutanol, urea methyl, metha crylate, and other products. A battery of by-product coke ovens is located at this plant. Below Belle the Malden salt works makes bromine and bromides from local brines and from concentrated bitterns shipped in from the Ohio Valley salt works.

Near Charleston two independent glass manufacturing plants, one making continuous sheet plate glass, and the other machine-blown bottles, combined their efforts to secure operational fuels. Company-owned gas wells are drawn upon and nearby gasoline plants are utilized in supplying fuel needs. A plant across the river from Charleston produces red lead, litharge, battery oxides, lead pigments, and other products.

Many of the largest industries of the valley are located in South Charleston, across the river from Charleston, and southwest of the city. A plant located in South Charleston in 1913 made barium oxide and other barium salts, using barytes shipped in from Tennessee. In 1924 the Carbide and Carbon Chemicals Corporation located here, having purchased a gasoline plant on Elk River, north of Charleston, and later

transferred experimental work to South Charleston. Hydrocarbons reaching the plant came first by tank car, but later cross country pipe lines were used. Its products are synthetic entanol, ethylene glycol, acetone, synthetic butanol, acetic anhydride, and other compounds and derivatives. Nearby Westvaco Chlorine Corporation operates mainly to supply chlorine to the Carbide and Carbon unit. Westvaco originally used local brines but later shipped in New York and Michigan rock salt, since it is not necessary by this method to purify pumped brines.

A wartime development was the plant at Institute to make synthetic rubber. Components used are butadiene from alcohol and styrene from the coal derivative, benzine. (Natural gas may be used in distilling commercial alcohol.) Farther downstream at Nitro a subsidiary of Monsanto Chemical Company and the Ohio Apex Chemical Company make chemical specialties. The lower Kanawha stresses agriculture rather than industry, although Point Pleasant has an established shipbuilding industry.

ECONOMIC FUTURE OF THE VALLEY

The valley likely will continue present economic activities, because mining and chemical product manufacturing are becoming more strongly entrenched in the upper and middle valley. Agriculture will remain dominant in the lower valley, but will decline in importance above Dunbar to Charleston. Coal will be mined for an indeterminate period in and near the upper valley, gas and oil production will likely decrease, and more salt will be brought in as local supplies are depleted. Additional labor can be recruited from nearby hill sections as continued chemical advancement elevates the Kanawha Valley in the American industrial picture.

MINERAL RESOURCES OF INDO-CHINA

E. Willard Miller

THE Annamites, and especially the Chinese, have extracted coal and metallic minerals for centuries from surface deposits in Indo-China. Evidences left by ancient workings have frequently proved valuable in rediscovering deposits. Although production from early exploitations was never large and was essentially abandoned when the French occupied the country, knowledge of existence of the mines was one of the principal reasons for French conquest of Tonkin. The modern mineral industry, which has been developed since 1885 by French capital, management, and technicians, is limited largely to Tonkin (Figure 1) because of accessibility of the coal deposits, better transportation facilities, and available labor supply. Value of minerals has risen from a total of about $240,000 in 1900 to $5,300,000 for coal and $3,000,000 for industrial minerals in 1939.

Development of Mining

Development of the mineral industries of Indo-China has been more rapid than that of the country's economy as a whole. Indo-China has remained a land of primary production; and since the economy is predominately agricultural, most minerals are exported. Production of minerals is essentially the only important modern industry, but its progress has not been uniform because of many physical and economic handicaps.

Development of mining was very gradual until World War I. The natural environment has always discouraged exploration and was particularly a hindrance when transportation was primitive. More than half the country is mountainous, with three systems trending from northwest to southeast. In northern Tonkin, between the Red River delta and the Mekong headwaters in upper Laos, massive limestone mountains with steep-walled canyons and high karst plateaus prevail. The Annam Cordillera, composed of a series of high ranges and plateaus, extends from one corner of the country to the other and effectively isolates interior Mekong Basin from the eastern coast. The third system are the mountains of southwestern Cambodia which are relatively low and limited in extent.

The lowland plains of the Mekong and the Red rivers are in striking contrast to the interior rugged topography, but they do not readily lend themselves to geologic exploration. During the rainy season vast areas are flooded. Dense vegetation grows in the lowlands and thick deposits of alluvium cover bed rock.

Prospecting in the interior of the country was practically impossible until after 1900 because of the banditry of the Black Flags, hostile tribes, and lack of transportation facilities. It was during this early period, however, that the modern foundations of the mineral industry were established. In 1902 the Service Des Mines was created to prepare systematic surveys of the surface and subsurface rocks of the country, and to investigate the mineral wealth. The maps were first prepared on a scale of 1/100,000 but this scale was abandoned for the more practical one of 1/500,000 which is now complete for most of the country. Two composite geologic maps at scales of 1/4,000,000 and 1/2,000,000,

which have been revised frequently from detailed reports, give an excellent general portrayal of the geology.

The earliest mining laws, passed in 1888, tried to prevent speculation by heavily taxing operating mines, which discouraged the active development of small deposits with a consequent great discrepancy between the number of prospecting permits issued and the number of mines under exploitation—1,224 to 215 in 1910. This led to a revision of the mining laws in 1912. Present laws are based on the principle of the claim stake so that any Frenchman can secure for about $7.00 exclusive right to make investigations in an area three kilometers square, oriented north-south, the center of which may be selected at any spot. Such patents are valid for three years and may then become permanent concessions by proper legal arrangements and payment of about $100. This method of securing concessions has undoubtedly hindered exploitation at times, and has stimulated speculation since the owner of a concession is not required to do any prospecting. Concessions are frequently obtained and held in hope that a mineral deposit may be discovered in the selected region.

Formation of speculative companies has also been encouraged by relatively low taxes since 1912 on the mining industry. The initial tax on the organization of a company is only 10 per cent of the capital stock, and there is a yearly tax of about $45.00 for each square kilometer held. A dividend tax of about 8 per cent is imposed, and the following production taxes are collected (1939):

	Dollars U. S.
Tungsten	3.50 per ton
Tin	7.00 per ton
Cassiterite	10.00 per ton
Iron ore	.05 per ton
Coal	.05 per ton
Ground phosphate	.10 per ton
Chromite	.15 per ton
All other ores	.50 per ton
Gold	8.00 per kg.

Issuance of patents and concessions is limited essentially to French citizens. Foreigners and foreign capital can enter Indo-China to develop the mineral wealth only under special diplomatic conventions. The French have always hesitated to invest in colonial enterprises, and because of mining failures during speculative periods have been reluctant to invest heavily in a sound mining policy in Indo-China.

FIGURE 1.—Commercial Mineral Deposits of Indo-China. The heavy concentration of mining operations in Tonkin reflects rather accessibility of fields to French capital, and modern methods and equipment, than commensurate potential distribution and value.

The first impetus for an expanded mining industry came during World War I as response to rising prices and rapidly growing Far Eastern market. Production of zinc and coal increased greatly. New deposits were developed and existing operations were expanded. At the close of the war, decline in prices, and general unsettled world economic

conditions caused a sudden slump. However, it was of short duration for in 1922 the price structure was recovering and one of the most prosperous mining periods in Indo-China began.

Mineral production by 1925 was sufficiently large and diversified to give mining operations wide publicity, often exaggerated, in France, which encouraged organization of a large number of companies, some for the purpose of actual prospecting and development of new deposits, others only for speculative purposes. Soon an unparalleled mining boom developed, with most activity centered in Tonkin and central and northern Laos. It was, however, a period of many failures, for most prospectors were inexperienced and usually unprepared to cope with the rugged topography and tropical climate. Although no new commercial deposits were discovered, the speculative bubble grew as fabulous stories were circulated and stocks sky-rocketed as response to rumor rather than actual mineral production. During the mining rush of 1927 to 1929, prospecting permits rose from 4,776 on January 1, 1928, to 17,685 one year later. However, the number of commercial mining concessions in operation numbered 350 in 1928 and only 352 in 1929. From 1920 to 1932 about $20,000,000 were invested principally in speculative projects.

The speculative bubble broke in 1930 with rapid decline of prices as result of the world depression. The number of patents in force fell to less than 1,000 in 1934 and total value of the mineral output for that year was only $3,000,000. Coal and zinc experienced the greatest decline. The productive curve in Indo-China is exceptionally sensitive to the world price structure because of complete dependence on the large export market.

The year 1935 marked the recovery of mineral production, and in 1936 the output of anthracite represented an increase of 30 per cent over the preceding year. Of the metallic minerals, tin and zinc remained most important, but a number of other metals such as manganese, chromium, and iron were produced in important amounts for the first time.

As a result of the great demand for minerals during the world armament race in the late 1930's, the markets for Indo-China's minerals grew rapidly so that by 1939, at the outbreak of hostilities, the mineral production was the highest in the country's history.

COAL

The anthracite coal production of Tonkin forms about three-fourths of the annual mineral wealth of Indo-China (Figure 2). Although coal has been mined for centuries by natives and Chinese, modern exploration by the French did not begin until about 1881 and the earliest concessions were granted in the coastal region of Hon Gay in 1887. Mining developed gradually for several decades because of the danger from coastal pirates and lack of either domestic or foreign market. Coal production, only about 200,000 tons at the

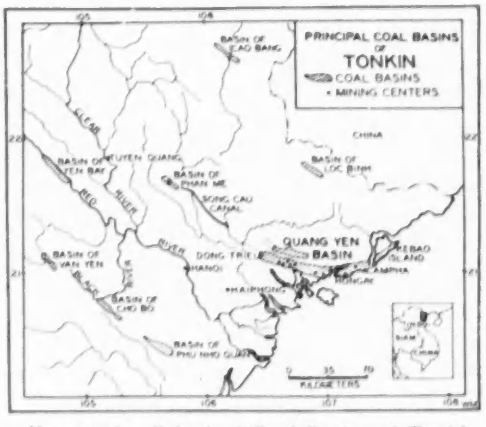

FIGURE 2.—Principal Coal Basins of Tonkin, indicating relatively wide distribution. Reserves are not of major magnitude.

turn of the century, rose to about 500,000 tons in 1913, and the peak output was reached in 1939 when nearly 2,500,000 tons were mined, 96 per cent of which was anthracite (Figure 3). This was about 2 per cent of the total Far Eastern coal production. Two large French companies have virtually monopolized production of anthracite, "La Societe Francaise des Charbonnages du Tonkin" mining 72 per cent, and "La Societe des Charbonnages du Dong Trieu" producing about 25 per cent of the total output.

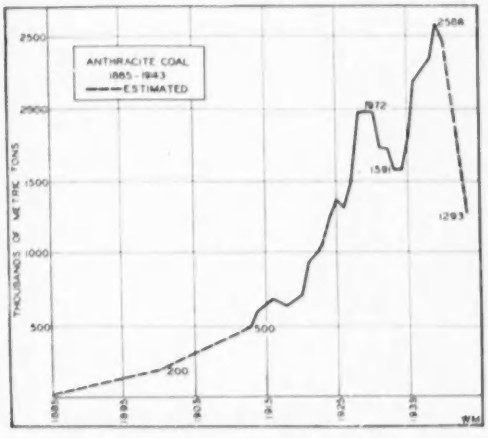

FIGURE 3.—Production of Anthracite 1885–1943. The significant increase in production the last 30 years represents an expanded market and demand, as well as improved methods and equipment. (Data from official report of the "Service des Mines," Hanci.)

The principal coal fields of Tonkin are located in the Quang Yen Basin (Figure 7). The beds extend in a great southward bending concave arc from Sept-Pagodes in the west 180 kilometers eastward to Tien Yen on the coast and to the southern shore of Ke Bao Island. The coal beds are contained in sandy, Rhetic schists and appear to be allocthonous, that is, formed from vegetation carried by the river from higher elevations and deposited in the basin. Many of the beds are warped, but most have only moderate slope. They are frequently irregular and many have been broken by faults. The thickness of the seams varies considerably. One bed near Cam-Pha has a thickness of 80 meters of marketable anthracite. In the Dong Trieu region the southern beds have a total recoverable thickness of 17 to 45 meters and the northern beds, 35 meters.

The anthracite coal of the basin is excellent fuel which burns without smoke, and gives little ash. With forced draft, it can be used alone to heat boilers. By mixing with bituminous, a good steam coal is obtained for use in locomotives. Average composition of the anthracite in the Hon Gay region is:

Volatile matter	8–11%
Fixed carbon	87–88%
Ash	2.5–7%
Sulphur	Less than 1%
Calorific power	7,800 to 8,000 calories

The coal is frequently brittle and therefore yields a high percentage of slack. The "Societe des Charbonnages du Tonkin" manufactures briquettes at Hon Gay composed of 70 per cent anthracite slack, and 30 per cent bituminous with pitch as binder.

Many beds outcrop on sides of slopes so that originally most of the coal was strip mined. Such deposits are nearing exhaustion and now about two-thirds of the coal is mined from shafts. Most of the coal is mined by hand labor, but mechanization began in the early 1930's. Roof props are usually wood, but steel supports are appearing in a few mines. Floods are the greatest mining hazards; and since a number of the mines were closed during the Japanese occupation, no doubt many of these are now filled with water.

The early exploitation of coal began because of its location on the Along Bay and near inland waterways accessible to ships of 6,000 tons. Meter gauge railways have now been built

from the coal fields to the shipping ports. The principal ports of Hon Gay and Cam Pha (Figure 6) have wharves and cranes, and at the latter, four electrically operated booms can load two ships at a time at the rate of 500 tons per hour. Port Wallot and Port Redon are secondary shipping centers.

The surveys of anthracite reserves in Tonkin are still incomplete. Lantenois estimated in a report for the International Geological Conference in 1913 from surface outcrops that the recoverable reserves were more than 20 billion tons. It is, therefore, evident that production could be increased considerably if the market warranted it.

A secondary deposit of anthracite is located in the Nong-Son Basin of Annam, approximately 30 kilometers southwest of Tourane. The anthracite, comparable in quality to that of Tonkin, is found in alluvial deposits which extend southwestward to the initial slopes of the Annamite range. The beds are about 15 kilometers long and maximum width is about 8 kilometers. Between 1910 and 1920, nearly 300,000 tons of coal were mined by open pit methods. With exhaustion of surface coal, the main mining operations were abandoned. On the northern edge of the Basin near the river Song-vu-Gia, one shaft mine produces 2,000 to 3,000 tons annually.

There are a number of bituminous and semi-bituminous producing fields in Tonkin. The Phan Me field is situated in central Tonkin north of the Red River. The field is elongated and folded parallel to the Red River, and the beds which outcrop in the low valley are nearly vertical. The coal seams are irregular and frequently broken by faults. The district produced about 43,000 tons in 1937, by shafts sunk to the depth of 125 meters. A 60 centimeter railroad transports the coal to the Song Cau canal and then by water to the delta region. Other bituminous deposits are found in the basins of Phy Nho Quan, Cho Bo, Van Yen, and Yen Bay located south of the Red River, but mining operations have been inactive in the areas since 1931.

Several lignite deposits have been discovered in northern Indo-China paralleling Red River. They are lacustrine sediments deposited in synclinal depressions during the Miopliocene period. The deposits have been worked intermittently. Beds at Tuyen Quang, opened in 1915, have yielded as much as 30,000 tons annually. Deposits at Dong Giao yielded from 1905 to 1911 nearly 100,000 tons of lignite, used as fuel for the railroad, "Reseau d'Etat Nord."

METALLIC MINERALS

Systematic development of the modern metallic mineral industry began in 1904 when tin and tungsten deposits were rediscovered in the Pia Ouac Mountain range of Tonkin. Cassiterite and tungstic anhydride ores are found in alluvial deposits in the karst basin of Tinh Tuc about 60 kilometers west of Cao Bang. The core of the Pia Ouac Mountains consists of granite residues penetrating primary schists which in turn have been contact metamorphosed

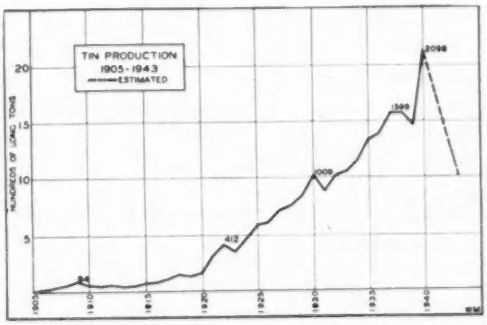

FIGURE 4.—Production of Tin, 1905–1943. In the last quarter century, tin production has multiplied many fold; except during the war, production increased steadily. (Data from official report of the "Service des Mines," Hanci.)

into aphanite. On the north and northwest the aphanite is traversed by large mineral veins. Through weathering, and later erosion, the enriched ores have been deposited in the Tinh Tuc Basin, in some localities to a depth of more than 40 meters (Figure 8). Cassiterite ores are mined entirely by the open pit method.

Transportation difficulties, lack of smelter facilities, and undeveloped marketing policies retarded early developments. In 1917, only 234 tons of tungstic anhydride and 78 tons of metallic tin contained in mixed ores were exported. In 1919 with the development of the alluvial deposits of wolfram in

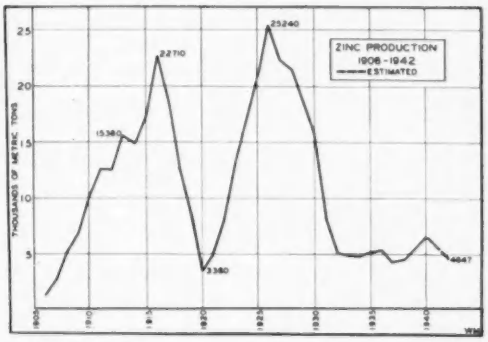

FIGURE 5.—Production of Zinc, 1906–1942. Zinc production has fluctuated through a wide range, reaching its peak in 1926, before low grade ores could be successfully treated and the metal won from them. (Data from official report of the "Service des Mines," Hanci.)

south China, the high cost ores of Indo-China could not compete successfully. Tungsten has remained essentially a by-product of tin mining. The highest production of 648 tons of tungstic anhydride occurred in 1937 as result of French attempts to encourage production of steel alloys within the Empire.

By 1922 tin production was sufficient to warrant building a furnace at Ta Sa near the producing area, and in 1929, when 386 tons of metal were produced in Tonkin, a larger reverberatory furnace was constructed at Cao Bang. Much of the Tonkin ore was exported after 1930 to Singapore where it was mixed with the lower grade Malayan ores because of its purity and high metal content. A road has been constructed from Tinh Tuc to Na Cham whence the ore is transported by rail to Haiphong.

The Nam Patene area in Laos which lies north of Thakhek is now the largest tin producing area in Indo-China. The deposit had been worked by natives who dug shallow shafts into the alluvium and produced from 10–15 tons of ore annually prior to 1920, most of which was sent to Siam by way of the Mekong River where it was used as ballast for fish nets. With construction of a road across the Annamite chain in 1923 from Thakhek through Savannakhet to the coast, and with improvement of navigation on the Mekong the deposit began to be worked systematically by the "Societe d'Etudes et d'Exploitations Minieres de l'Indochine." Production rose to 200 tons in 1925, and in 1930 surpassed that of the Tonkin mines.

The cassiterite is found as an alluvial deposit in a karst basin which is approximately 30 kilometers long and eight wide. The eluvial cassiterite is joined in depth to the veins which pass through the muscovitic sandstone subjacent to the limestone, and which have been metamorphosed by granite intrusion. The ore, which is about 10 meters thick, is mined in open pits by a force of more than 6,000 Annamites. The ore is not rich as that of the Tonkin beds and is partially processed at the mines by crushing, working and magnetic separation. The concentrates are then sent to Singapore to be refined.

The production curve of tin had been continually upward until 1940 (Figure 4) and had not experienced great fluctuations such as in the case of zinc. Since 1928, when its value surpassed that of

zinc, tin has had the greatest value of all metals produced in the country. In 1929, when world tin prices were declining, the Tin Producers Association was organized to bring about a general curtailment of production. This was known as the Bryne Plan. The quota for Indo-China was set at 3,000 tons. At no time has production approached this quota, and therefore Indo-China has benefited from the rise in prices without necessity of curtailing production. In 1940, 2,098 tons were produced, of which approximately 60 per cent came from the Nam Patene district and the remainder from Tinh Tuc.

The modern zinc industry began in 1905 when the ancient native workings were reopened at Trang Da which lies north of Tuyen Quang between the Red and Clear Rivers. The Indo-Chinese and Chinese originally extracted ore to make their sapek coins. With opening of other mines in the same district at Lang Hit in 1906, Cho-Dien in 1908 (Figure 9) and at Yen Tinh in 1909, value of zinc surpassed all other minerals. The ore is found in massive primary limestone in which a complicated pattern of fissures has been mineralized. Calamines (carbonates and silicates of zinc) occur close to the surface, and at shallow depths, blende, (zinc sulphide) is found. The calamine deposits furnish most of the zinc present.

Production of zinc has not been uniform (Figure 5) but has varied according to the export market which depends on world prices, government support, currency devaluation, and advancing technology. Peak years of zinc production were in 1916 and 1926. Drastic decrease in 1920 caused particularly by the depressed condition of the Japanese smelter industry resulted from loss of its Russian market after the revolution. The colonial government granted premiums on each ton of zinc sold and the excess stocks were liquidated by 1922. Rising prices resulted in production of 25,240 tons of metal in 1926, the highest production in the history of the country. Until 1924 all the ores were exported directly, but in that year a three-furnace foundry, with a capacity of 6,000 tons, was constructed at Quand Yen, near Haiphong, and since then most of the ore has been converted into metal before being exported. The ore is

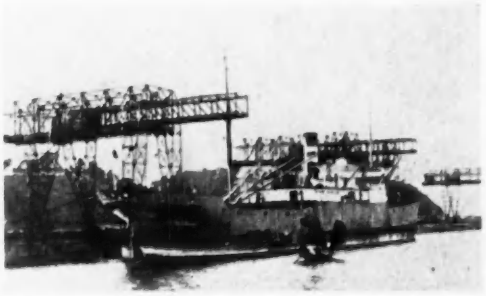

FIGURE 6.—Coal loading facilities at the port of Campha, where four electrically operated cranes can load two ships at a time, at the rate of 500 tons per hour. (Courtesy of Gouvernement General de l'Indochine.)

transported by cable car into the Bau Thi Valley, where a railroad carries it another 35 kilometers to the Song Guam, a tributary of the Clear River, and then by water to the foundry.

Production declined rapidly from 1926 to 1932, but has remained stabilized at about 5,000 tons since then. The decreased production is due in a large degree to the invention of the flotation and electrolytic process, in which zinc can be extracted cheaply from low grade ores previously neglected or as secondary metal when associated with other ores. The process has not been introduced into Indo-China and low grade ores cannot be exported because of high transportation costs. Therefore production is limited essentially to refining capacity of the country. Reserves of low grade ores are large so that production could

be increased if technical advancements are introduced.

A number of commercial iron ore deposits have been located in Indo-China, but development has been hampered by inaccessibility of most areas. Greatest output occurred in 1939 when 136,000 tons of ore were mined. The largest mines are located in central Tonkin near Thai-Nguyen and Tuyen Quang, and an open pit deposit on the island of Ke Bao yields between 15,000 and 20,000 tons annually. Small iron smelters are located at Dap Cau, Bac Son and Haiphong. Large deposits of hematite and magnetite have been located in the Phnom Deck Hills, north of Kompong Thom, in Cambodia, near Vinh and Thanh Hoi in northern Annam,

FIGURE 7.—Slope coal mining in the Quang Yen field, where the principal deposits of French Indo-China are located. (Courtesy of Gouvernement General de l'Indochine.)

and at Bao Ha and Lao Kay in northern Tonkin; but little ore has been mined. The development of most of the deposits can proceed only after transportation facilities are constructed, and possibly a rise in world prices.

A number of other ore deposits have been discovered in Indo-China, but demands have not been sufficient to encourage large-scale exploitation. Annual production of manganese has varied from 2,000 to over 5,000 tons from mines situated around Yen Cu, near Vinh, and in northern Annam. Many deposits are known in northeastern Tonkin and the reserve of ore is estimated to be 25,000,000 tons. Low price of manganese in the 1930's and remoteness of the deposits have prevented their development. Approximately 2,000 metric tons of chromium were produced in 1939 from deposits at Thanh Hoi. Antimony has been mined intermittently near Bao Lac, Dong Khe, and Mon Cay in northern Tonkin and southeast of Thanh Hoi in northern Annam. In the Cao Bang area a single deposit contains an estimated 250,000 tons of marketable ore. Deposits of bauxite have been mined near Lang Son and Haiphong in eastern Tonkin and at Quang Nam in central Annam. The 1938 production was over 50,000 metric tons of ore. A few minor lead deposits have been developed at Ngan Son and Tu Le in Tonkin, but production has never been more than 250 tons annually and output practically ceased after 1935. A number of copper ore deposits have been located in Indo-China, but by 1939 no production was reported.

Gold is found in alluvial deposits along many of the mountain streams, and native mining is practiced in many places. The operations are seasonal and yield small returns. The only European mine in 1939 was at Bong Mieu in central Annam about 150 kilometers southeast of Tourane. The mine operated from 1895 to 1919 and then was inactive until 1933 when a small hydro-electric cyanide processing plant was constructed. The smelting produced a 40 per cent gold concentrate which was sent to France for refining. Total production of Indo-China has been about 300 kilograms per year.

NONMETALLIC MINERALS

Indo-China has large reserves of phosphate, but prewar production was always small. In 1938, the peak year, 37,341 tons were mined in the Lao Kay region of Tonkin and the Thanh Hoi area of northern Annam. The Lao Kay deposits lie close to the Kunming-Hanoi railroad, and reserves of high grade rock have been estimated to be 10,000,000 tons, and including the lower grades, nearly 50,000,000 tons of phosphate rock. Other deposits in Tonkin are found near Lang Son, at Thai Nguyen and along the Red River. In Annam some deposits are known at Vinh and Dong Hoi. In Cambodia there are deposits at least at two localities, one in the south at Kampot and the other near Battambang. Phosphate processing plants are located at Battambang, My Tho, Vinh and Haiphong.

The extraction of corundums, particularly sapphires, and rubies, and some zircons and tourmalines, has been of some importance on the alluvial plains at Pailin, south of Battambang, and at Bokeo in Cambodia. At the turn of the century when the territory was part of Siam about 10,000 people were employed, but the larger stones seem to have been exhausted and the total value of the production had fallen to about $20,000 in 1937.

Graphite has been mined near Lao Kay, but operations were suspended in 1931 at the start of the world depression and mining has not been resumed.

LABOR SUPPLY

The mining industry of Indo-China employs about one-half of 1 per cent of the active workers of the country. In 1937 the mines employed 271 Europeans who were the skilled technicians and managers, and 49,200 Asiatics. Of the number about three-fourths were employed in production of coal. As established by law maximum proportion of foreigners including the French which could be employed was 10 per cent of the total workers in the coal industry

FIGURE 8.—Tin mines of Tinh Tuc, in alluvial deposits in the karst basin about 60 kilometers west of Cao Bang. (Courtesy of Gouvernement General de l'Indochine.)

and 5 per cent in all other mines. The Chinese were originally used in largest numbers for they are more energetic and exhibit greater skills. However, in recent years Annamites have been replacing them so that by 1939 they formed 90 per cent of labor in the mines. The Annamites are less skilled and sturdy than the Chinese, but they work for lower wages and are more easily disciplined.

Early working conditions in the mines were frequently deplorable. The coal mines in the Quand Yen Basin were known for many decades as "the hell of Hon Gay," and the Nam Patene tin region had earned the name "death valley." In 1931, under the direction of the Pasteur Institute, a number of measures were undertaken to improve health conditions of the mining centers. Since malarial fevers were prevalent, pools where mosquitoes bred were drained or sprayed with oil and Quinine was distributed, particularly to night crews. With application of such measures the death and sickness rate immediately improved.

One of the principal problems of the Annamite labor supply is its instability. Most of the operating mines are not situated near the areas of excess labor and workers must be imported from the outside. It is part of the social custom of the Annamites that they must return at least once during the year to their natal village. Since the Annamites prefer farming to working in the mines, the labor supply varies with the harvest months. In 1931 for every 100 workers in the coal mines after the Annamites' New Year festivities, there were 55 during the fifth month harvest, and 66 in the seventh month.

The traditional method of securing labor for work in the mines is through the Annamite labor contractor or "cai." This method has not developed a permanent mining class. Although this system has many defects, it has certain advantages indicated by M. F. Blondel at a hearing of the Committee on Indo-China in 1936:

> "Certain types of work cannot be effectively carried out except by subcontracting; this is especially true of some of the tin mines in the Upper Tonkin basin, which are located in the inaccessible mountainous regions. These mines are widely separated and sometimes several hours journey from the residence of the European overseer. They cannot be worked except by small crews from whom the ore is bought once a week through the crew foreman."

Beginning in the early 1930's a number of the mining companies, particularly in the coal fields, instituted policies to stabilize the labor supply. The "Societe des Charbonnages du Tonkin" has undertaken recruiting of its own workers, and construction of permanent villages near the mines. Each village has its own infirmary and modern sanitation facilities. Larger communities have company hospitals, schools, and athletic fields.

As the mineral industry develops in Indo-China, mining methods are becoming increasingly complex. The trained miner is a necessity with the introduction of underground mining, increased mechanization and the application of modern safety devices. Although the large coal companies opened a school in 1930 to train native workers, native technical labor and capital still play an insignificant role in management and organization of the mining industry.

INTERNATIONAL TRADE

Agricultural products comprise over 90 per cent of the value of the exports of Indo-China of which rice alone represents two-thirds of the total. The exports of mining products has, however, shown the greatest relative increase of all products since 1900, not only in tonnage but also in value. Exportation

of mining products increased from $1^3/_{10}$ per cent of the total value in 1900 to 7 per cent in 1937. In 1900 only 15 per cent as much coal as rice was shipped. By 1930, when coal surpassed rice for the first time, the relation of coal to rice tonnage was 118 per cent.

Export of coal has risen from about 200,000 tons in 1900 to 1,500,000 tons in 1939 which made Indo-China the tenth largest exporter of coal in the world, nearly two-thirds of her total production. With exception of China and Manchuria, Indo-China was the largest exporter of coal in the Far East. Of the five Far Eastern coal exporting countries (Indo-China, China, Manchuria, British India, and Netherlands Indies), Indo-China exports approximately 20 per cent of the total net amount. Japan, taking 673,000 tons, and China 480,000 tons in 1938 were principal buyers. Export of coal to France grew from 30,000 tons in 1930 to over 250,000 tons in 1938 as result of French attempts to develop closer economic relations with her colonies. Other markets were being developed in which the United States received a small amount of coal. Growth of the export market was based on high quality and a strong commercial organization.

The entire metallic mineral output of Indo-China is exported. Until 1914 the tin ore was sent to Singapore and the zinc ores were exported to Europe where Germany was the principal buyer. During World War I, when the European countries were blockaded, markets were found in the Far East. The Japanese industry was developing rapidly at that time and needed the minerals of Indo-China. Exports to China, particularly zinc, also increased. The dominance of the Far Eastern market continued until the beginning of the world depression in 1930. As general world-wide trade restrictions were imposed, France became an important buyer for the first time. France received the entire production of zinc, tungsten and all tin refined in Tonkin. The tin ore

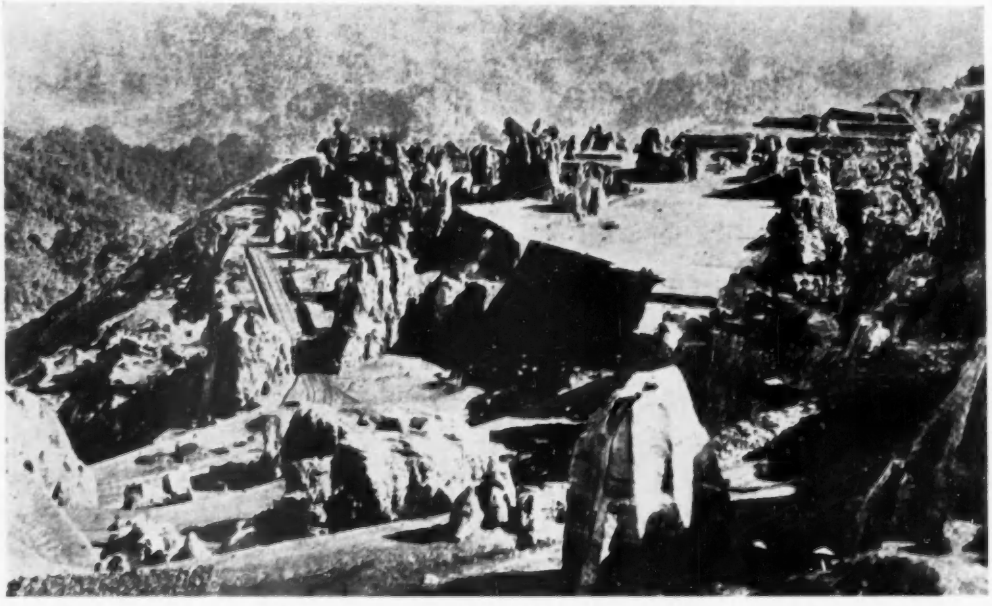

FIGURE 9.—Zinc mines at Cho-dien, opened in 1908, where the ore occupies a complicated series of fissures in massive primary limestone. (Courtesy of Gouvernement General de l'Indochine.)

of Nam Patene has always been sent to British Malaya. Japan continued to receive all of the iron, chromium, and manganese ores. In 1939 Indo-China was the world's sixth largest exporter of tin ore and concentrates, eleventh largest exporter of refined zinc and ranked twenty-third as an exporter of iron ore.

INFLUENCE OF JAPANESE OCCUPATION AND PRESENT OUTLOOK

Information concerning the influence of Japanese occupation of Indo-China on the mineral production is still largely lacking. It is known that the economic system of Indo-China was correlated with that of Japan in 1941 and quotas for mineral production were established. Japan took the entire export. Coal production decreased to about 800,000 tons per year because of lack of shipping space. Iron ore production practically ceased, and the zinc and tin output decreased considerably. The production of phosphate at Lao Kay increased greatly, and output of chromium and aluminum ores, originally of limited importance, appears to have attained sizable proportions.

After defeat of the Japanese in August 1945, the French re-established political control of the country. Internal disturbances ensued to hinder general economic recovery. Although it is estimated that the 1946 mineral production will be lower than in any year of the Japanese occupation, the large proved reserves of minerals, and the excellent possibilities of discovering new deposits with more intensive surveys promise recovery and continued growth for the mineral industry of Indo-China.

PHYSICAL ASPECTS OF THE LARAMIE RIVER DISPUTE

Clark N. Crain

IN recent years, problems involving distribution of the waters of interstate streams in the arid and semi-arid West have become more and more acute. By 1910, many interstate streams had become over-appropriated by rapidly growing irrigation districts throughout the West. Continued expansion of the irrigated areas led to serious legal conflicts among various states in whose borders unplanned appropriation of waters had been going on without regard to the needs or future of other states through which the streams flowed. The years from 1910 to 1930 were characterized by endless stream of legal battles over the problems, but it was not until the widespread drouth conditions which developed in the 1930's that the problems became so aggravated as to draw attention of the general public.

One of the problems has been of vital interest to the great irrigated farming districts of northern Colorado and Wyoming and has resulted in a serious threat to security of the meadow land ranchers in the Laramie Valley in Colorado. The problem involves the waters of the Laramie River which rises in the Medicine Bow ranges of North Central Colorado and flows north some thirty miles into Wyoming where it joins the North Platte River. In 1911, Wyoming brought suit in the United States Supreme Court to deny Colorado interests right to divert, by means of a proposed tunnel, waters from the basin of the Laramie to the Cache la Poudre River for use in the Fort Collins–Greeley farming area to the east. The Cache la Poudre drains into the South Platte River which flows into Nebraska, missing Wyoming. One of Wyoming's complaints was that the water could never reach her territory.

The government of the state of Wyoming alleged that the proposed diversion, by means of the Laramie-Poudre tunnel, from the Laramie River to the Cache la Poudre River in Colorado would be injurious to prior appropriations on the Laramie River in Wyoming. Both Wyoming and Colorado recognize the doctrine of prior appropriations, Colorado claiming the right to use of all waters within her borders by reason of her sovereignty of statehood. Wyoming contended that priority, regardless of state lines, should apply on interstate streams, and that Wyoming, having prior appropriations of sufficient volume to use practically all waters of the stream, was entitled to full protection.

In its decision, the United States Supreme Court rejected any consideration of Colorado's contention that since the Cache la Poudre Valley (in Colorado) was more productive, she should be granted special rights. The contention was based upon belief that the area around Ft. Collins and Greeley in the Cache la Poudre watershed would be more productive than areas involved in Wyoming, and thus should be developed at expense of less productive areas, involving direct diversion of waters from one basin to another. The Supreme Court refused to allow the

contention, feeling that Wyoming was entitled to a full flow in the river.

Following this, the Supreme Court attempted to allocate the entire flow of water in the Laramie River between Colorado and Wyoming. The court arrived at its allocation by first determining the total supply furnished by the stream as being 288,000 acre-feet. It then recognized existing appropriations amounting to 272,500 acre-feet in both states. The appropriations were then deducted from the total supply leaving a balance of 15,500 acre feet, which was allocated by the court to the diversion through the Laramie-Poudre tunnel into the Cache la Poudre watershed. Although the Laramie-Poudre tunnel was the most junior appropriator on the stream in both states, the decision had the effect of making it a senior appropiator, since now, according to this decision, the tunnel could take its full allotment of 15,500 acre-feet yearly, regardless of the amount of total flow, whereas earlier, and therefore truly senior, appropriators in Wyoming have been denied waters in years of subnormal stream flow.

On October 6, 1930, Wyoming filed a second suit against Colorado involving the interpretation of the decree of the United States Supreme Court of 1922. This suit was filed in an attempt to correct the situation involving the Laramie-Poudre tunnel. On June 1, 1936, the court announced its decision, sustaining contentions of Colorado that the quantities of water, theretofore recognized by the court in the former case as having been diverted from the Laramie by the Colorado agency, were in the nature of a lump allocation to Colorado as a state, and not as separate allocations to individual users, and that Colorado could rightfully administer such water under the provisions of its own laws without violating the interests of Wyoming, provided only that it would not divert more than its quantum of 39,750 acre-feet per year. (This amount of 39,750 acre-feet per year was the total amount determined by the Supreme Court in the 1911 decision as the amount to which Colorado was entitled, including the 15,500 feet allotted to the (diversion).

In the 1911 decree, the Supreme Court used the words "divert and take" with reference to the total amount of water to be diverted from the Laramie River within Colorado. With reference to the use of this water on the meadowland of the Laramie Valley within Colorado, the state of Colorado interpreted the words "divert and take" to mean a consumptive use and not head-gate measurements. However, in the 1936 decision the court held that normal diversions in the meadowland ditches resulted in unnecessary use of water, amounting to waste, and that use of water on wild meadowlands in Colorado should be measured at the headgates of the ditches instead of being measured as to the total use on the fields themselves. The effect of the ruling was to limit the meadowlands to a total of one acre-foot per year of water, this acre-foot to be measured at the head-gate and not the actual amount placed upon the field.

Unlike the diversified agriculture practiced in the Cache la Poudre valley, the meadowlands, at an elevation of about 9,000 feet, require somewhat different practices in applying water to the fields. Their main crop is wild hay, which grows here in abundance, providing it gets sufficient water. However, the ordinary type of sheet irrigation practiced in lower elevations is not effective in the growth of this particular type of crop, which requires actual flooding of the fields over long periods of time during

the growing season. Because of the necessity of flooding the area, enforcement of the decree would have the effect of critically cutting down the productivity of the greater part of some 4,250 acres of hay land, upon which the entire Laramie Valley is absolutely dependent.

Because of the importance of the decision to residents of the Laramie Valley, Colorado was given until September 15, 1938, to file application for a rehearing in respect to that part of the decree relating to the meadowlands, and the court denied Wyoming's demand for an interstate bailiff to administer the waters of the stream, leaving the administration in the hands of the respective state engineers as before. Despite the opportunity for rehearing, however, Colorado felt, from the wording of the judgment, that rehearing on the meadowland clause was useless, for the court declared that "consumptive use" was an ambiguous term which could not be carefully defined, and that water taken for "consumptive use" could not be accurately measured. Further, the court held that the term "return flow" was equally ambiguous and that it was impossible to show, by any accepted method, a usable rate of return flow to the river of the waters used on the meadowland. Furthermore, the court had refused to consider contentions of Colorado (a) that one acre-foot diversion measured at the head-gate was not sufficient quantity properly to irrigate the meadows, and (b) that regardless of the amount of water turned into the meadows, a very small percentage was actually consumed, the remainder returning to the stream (in surface run-off or sub-surface flow).

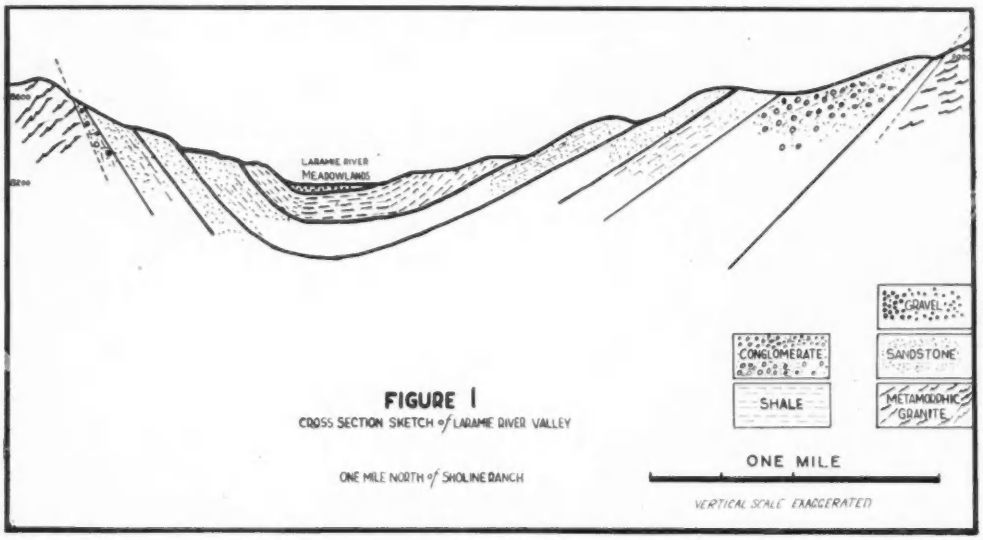

FIGURE 1.—Cross section of Laramie River Valley indicates that the stream flows along a closed trough within an impervious top layer of Cheyenne shale underlain by the equally impervious Niobrara shale, making the trough practically water-tight.

Enforcement of this decree by the Colorado officials meant virtual ruin to meadowland ranchers in the Laramie Valley. State officials had the unpleasant duty of following the decree of the court and thus forcing financial ruin on a section of the state, whose interests they were sworn to protect. The ranchers, feeling that they were being unjustly deprived of water rights

which they held by ancient decrees, became bitterly resentful of state officials whom they felt had sacrificed the meadowland in an effort to promote claims of influential "transmountain people." (Referring to the owners of the Laramie-Poudre diversion tunnel, whom the ranchers feel are partly responsible for their plight.)

In the meantime, October 15, 1934, Nebraska, anxious to develop her irrigated areas, brought suit against Wyoming, claiming that Wyoming's use of the waters of the Laramie River and the North Platte River had prejudiced areas in Nebraska dependent upon North Platte waters. In the new case, Colorado was interpleaded as a user of tributary waters. Nebraska v. Wyoming U. S. 79 L. ed. 1289 (pg. 1291). Wyoming now found herself in substantially the same position with respect to Nebraska's claims as that in which Colorado had been with respect to Wyoming's claims. In the Wyoming valley of the North Platte River and its tributaries, many thousands of acres of hay land were in danger. Wyoming suddenly became less critical of claims of Colorado's ranchers, and, though still firm in her determination to allow no excess transmountain diversion, passively tolerated use of large quantities of water in excess of the decree on the Colorado meadows. Colorado officials, never anxious to enforce the new decree, eagerly grabbed at the respite and allowed continuance of larger diversions from the Laramie to the meadowlands.

Despite the apparent consent of Wyoming to use by the meadowland ranchers of water in excess of their allotment, Wyoming filed a petition against Colorado before the Supreme Court on March 23, 1940. In this, she charged that Colorado had, between May 1, and July 11, 1939, diverted onto the meadows an excess of 12,673 acre-feet above its decrees, and that the total Colorado diversions exceeded the Colorado allotment by 24,775 acre-feet. Because of the excessive diversions, Wyoming brought suit for relief in the court and asked that Colorado be held in contempt and enjoined from making further diversions in excess of the 1936 decree.

In this new suit Colorado set up two defenses to the charge, one by the

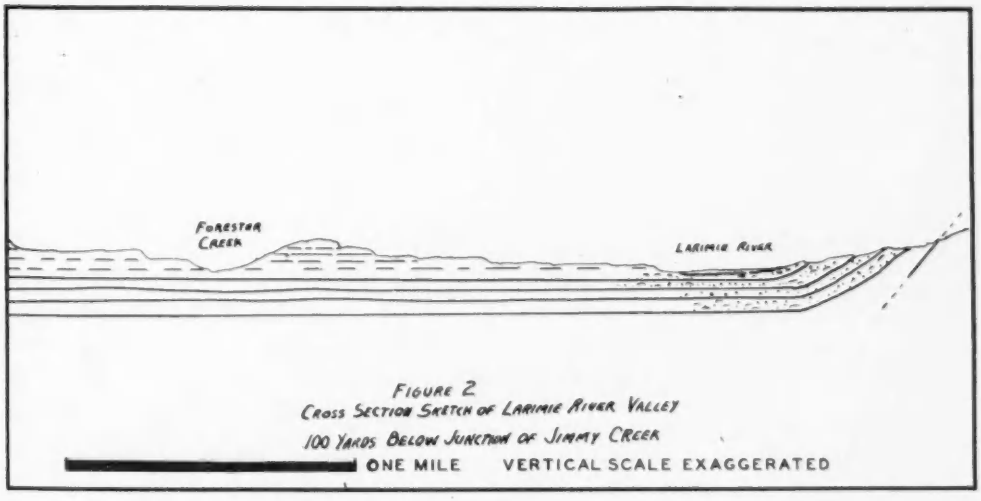

FIGURE 2.—Below Holzworth's ranch, Laramie Valley broadens out upon a modified monoclinal fold, which would not permit excessive drainage loss of irrigation water.

governor, the other by the attorney-general. The Colorado attorney-general, Byron Rogers, contended that Wyoming had not been injured by the excess diversions. Governor Ralph Carr, ordered Rogers removed from the case on the grounds that Rogers' contention had the effect of aiding one group within the state at the expense of another group. He set up the defense (1) that Wyoming had consented to the excessive diversion, (2) that Colorado was entitled to administer the water according to her own laws, and (3) that return flow from the meadows was so high as to allow great diversions to the meadows without materially depleting the material flow.

Both Attorney-General Rogers' and Governor Carr's defenses were heard by the court, but only Governor Carr's contention of consent by Wyoming were held valid by the court, the court refusing to allow the doctrine of return flow, holding that that question had been previously disposed of. The court held, however, that Wyoming's consent was apparent enough to relieve Colorado of contempt, but she was enjoined against further practice of excessive diversions.

The *other* question involved by Governor Carr's answer, that of administration of waters within the state, was also clarified, the court upholding interpretation of the 1936 decree by the district court of Larimer county, Colorado, in Adelrick Benziger vs. Water Supply and Storage company, *et al.* (February 2, 1939). In this case the district court held that the "court decree does not stop Colorado from administering the water under the decree according to her own laws" and to her own decree holders, providing the aggregate amount diverted from the Laramie does not exceed 39,750 acre-feet. The interpretation had the practical effect of reversing the decision of the 1936 decree concerning allocations to the separate interests within Colorado. The decree thus giving Colorado a lump allocation of 39,750 acre-feet to be distributed among her various decree-holders according to Colorado law, therefore stands according to the decision.

By the doctrine of prior appropriation, when water is flowing past the gate of a senior appropriator, a junior appropriator is entitled to take it. Since raising a sufficient hay crop demands steady supply of water during the growing season, the doctrine proved detrimental to the ranchers, for they could not save part of their share of the water for use in late summer. Uncontrolled rush for water resulted in exhaustion of Colorado's quota by June 17, 1940, and all Colorado appropriators were without water after that date. Since the decree of 1940, the Colorado ranchers have chafed under limited supply of water and have in many cases, no doubt, surreptitiously increased their own diversions. They have never accepted the justice of the last decree and have planned continuously since that date to reopen the case and again try to get a more equitable decision from the Supreme Court. The only thing which has prevented their seeking a new decision before this has been inability to find a really secure argument with which to present their case to the Supreme Court.

The decisions of the Supreme Court, based on an attempt to give each state involved an equitable share of water has been influenced to a great extent by ability of the states involved to present arguments on fine legal points and scientific evidence of one kind and another. Unfortunately, the courts have almost always followed an old idea that any water taken from a

stream for irrigation purposes depletes flow of that stream in direct proportion to the amount diverted. Thus, through the long series of disputes over the Laramie River, Colorado was allocated a share of the Laramie River water based upon a specified total amount of water diverted from the stream on an inflexible formula, without regard to number of acres to be irrigated with this water. The state was to administer the water (allocated in a lump sum to the state) among holders of the various water rights. In the case the allocation to Colorado represented a distinct penalty against Colorado due to its failure to present the case before the Supreme Court in such a way as to influence the decision. No recognition was made of any physical facts which would tend to illustrate return of any of the water to the stream nor that the resultant amount available to Colorado farmers was, by and large, entirely inadequate to maintain production along water right lands of the stream.

However, on October 8, 1945, the Supreme Court handed down a decision in the case of the State of Nebraska vs. the State of Wyoming, (the State of Colorado was impleaded, and the United States of America was intervenor). The case had to do with a demand on the part of the State of Nebraska that its right to water in the North Platte River be protected from over-use by Wyoming, or by Colorado with respect to certain of the tributaries. For the first time, the Supreme Court openly recognized the fact, that, under certain circumstances, amount of water diverted from a stream does not necessarily indicate total loss to the stream; and accepted a formula whereby the percentage of water diverted from the river which will return to the river can be measured. Thus, in this case rather than allocating to Colorado a specific amount of water, measured in acre-feet, it stipulated instead, the total number of acres which can be irrigated from the North Platte system in the region under question without regard to the amount of water per acre.

The decision opens up a whole new concept in determination of what is meant by equitable distribution of the water of non-navigable streams as between states, and points to possibility of a much more acceptable and just settlement of many disputes in the Rocky Mountain West. For example, if the principle is to be followed in future decisions, it can be definitely established that the diverted onto adjoining fields of the Laramie River cannot be lost by run-off, and the only appreciable loss would be through evaporation and transpiration, both measurable processes.

Furthermore, under terms of the decision of October 8, 1945, the Supreme Court retained jurisdiction over settlement of North Platte River water. Although the decree specifically excludes the previous decision concerning the Laramie River from the decision, the case probably could be reopened on basis of the fact that the Laramie is a major tributary to the North Platte system.

If the case can now be reopened and if the Supreme Court will agree to reconsider its previous decision concerning return flow, Colorado should be able to present very definite evidence in order to support claim of a high rate of return flow in the Laramie River Valley.

The Laramie River rises at an elevation of about 11,000 feet in the Medicine Bow Range of the Rocky Mountains of northern Colorado. From its source it quickly tumbles into a distinct north-south valley known as the Laramie River Valley. The upper third of the

valley is a typical Alpine valley, with steep walls and flat floor resulting from well-developed valley glaciation. This part of the valley is well delineated by a distinct terminal moraine just north of Middle Mountain. North of the terminal moraine the valley broadens out and the walls of the valley are less abrupt. Broadening continues northward as far as Bull Mountain where it becomes a very gentle depression, then gradually deepens again toward the state line.

Where the valley is now found, was once apparently part of the Rocky Mountain peneplane. Subsequent uplifts appear to have been accompanied by a long, parallel pair of faults, branching out from an area about where Chambers Lake now is, to the south of the head of the valley, and extending northward at a slight angle to each other.

Evidence of the faults may be observed along edges of the Laramie Valley, and is especially noticeable north of the terminal moraine. That Medicine Bow Range and Green Ridge, which parallel the valley, are composed almost entirely of crystalline rock, whereas the valley itself seems to be a distinct syncline composed of a common series of sedimentary rocks, is further distinct evidence of faulting on the sides. Thus this valley becomes a definite example of a closed synclinal trough, especially below the glaciated portion. The materials composing the series of

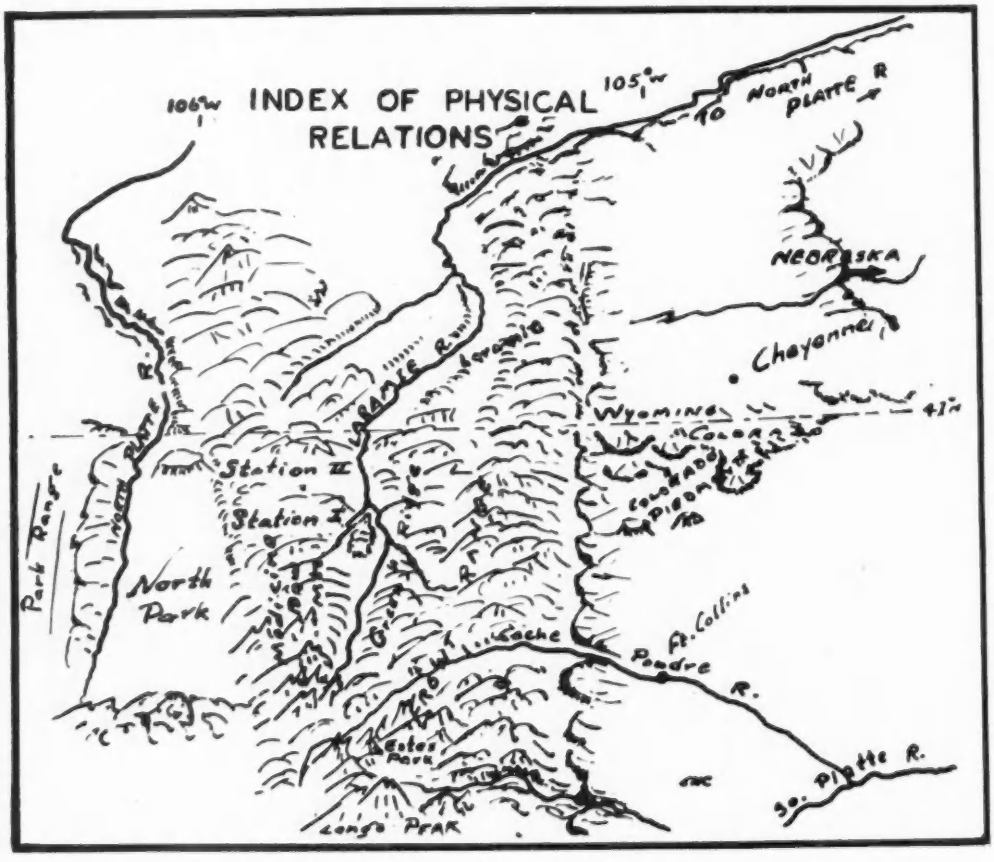

FIGURE 3.—Sketch of location and relationship of the drainage basins and systems of upper Laramie, North Platte and Cache le Poudre Rivers.

sedimentary rocks within the valley itself are relatively easy to distinguish, since the ends of many of the beds are exposed along the valley walls. Thus a cross section here is easily obtained by simply projecting the angle of the syncline and the approximate thickness of the beds. It is thus possible to show a relatively accurate picture of the valley bed. The cross section would indicate that the stream flows along a closed trough composed of a very impervious top layer of shale, known locally as Cheyenne shale. Other beds, such as the impervious Niobrara shale lend further strength to the belief that this trough is practically water tight. (See Figure 1.)

Throughout the length of the Colorado section of the river there has been discovered only one spot where leakage of water from the valley appeared at all possible. Near the Holzworth Ranch, there is a very sharp anticlinal fold within the syncline, and as is typical, the crest of the fold has been eroded for a distance of about 200 yards along the top. The gap might permit leakage of water down the strike away from the valley. However, it is insignificant since along the anticline, meadows do not warrant use of extensive irrigation and thus the amount of any water that might there be lost becomes negligible. Below, the valley broadens out into a modified monoclinal fold. (See Figure 2.)

Near headwaters of the Laramie, water is diverted by a tunnel through Green Ridge into the Cache la Poudre watershed, which serves the eastern country of the Cache la Poudre river in Larimer and Weld Counties, Colorado. Whatever water is diverted through the tunnel is definitely lost from the Laramie watershed and should be considered as a separate phase of the problem of distribution of the waters. Since diversion of water represents a definite loss from the Laramie River itself, it seems probable that it is necessary definitely to delimit the total amount of water available for the diversion.

Careful tests with colored dyes on the

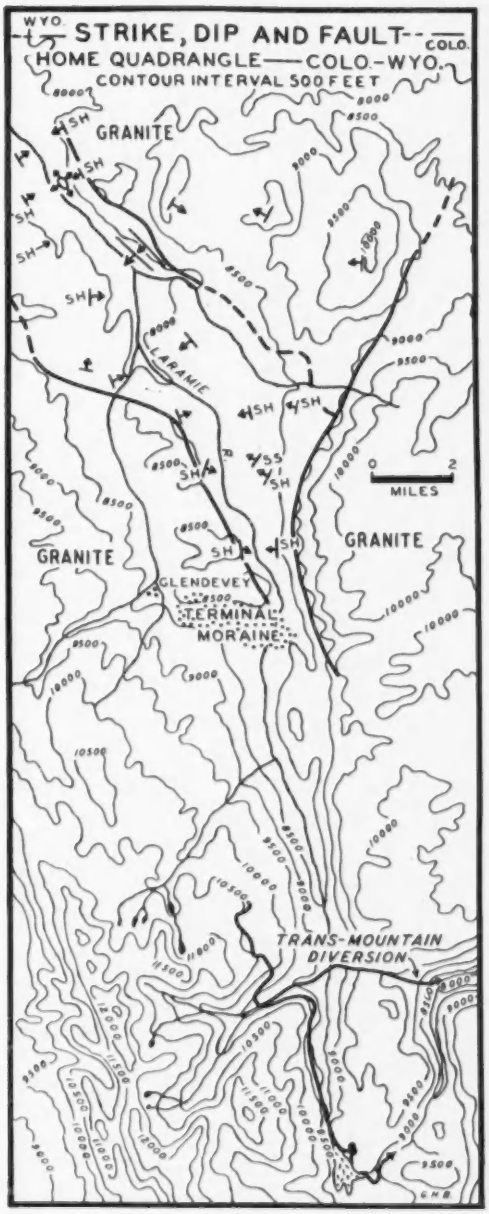

FIGURE 4.—Statigraphic and structural relationship of the area of transmontane diversion of water from the Laramie River headwaters to the Cache le Poudre valley.

Laramie River area have indicated a very definite return flow of water into the stream from the field. The heavy, loose gravel deposits which underly the actual meadowlands themselves, and which is indicated in both Figure 1 and 2, act as a natural passageway for the water after it has seeped through the top-soil into this area below. Since underlying strata are so impervious that water is practically debarred from passing through it, whatever water seeps through the top-soil is definitely held into the channel. Tests with dyes indicated that frequently the water would not return to the river until it had passed for several miles down stream in the underground channel, which does not act like an open conduit but simply is a course for the movement of large quantities of underground water. In one case small amounts of dye were dropped into the water at the head-gate at the point where the stream enters the Sholine ranch. Careful observation proved that large quantities of water found their way back into the stream and were sufficient to color the main stream at a distance of some three miles below the point at which the water was spread out onto the meadows. Most of it was underground return flow.

Careful scientific measurement of the water can probably be made, and the figures obtained would unquestionably stand up in a court of law if the Supreme Court will re-open this case. Also, tests should be conducted to establish imperviability of underlying strata. Further studies should be made to determine exact quantity of water lost to the air through evaporation and transpiration from the plant. Thus, by proving that the area itself will not permit loss of water from the valley by underground flow and by determining amount of water lost by transpiration and evaporation the quantity of water actually used can be definitely established.

It may be presumed, therefore, that the Supreme Court, following its decision of October 8, 1945, will be willing to accept such scientific evidence in order to settle this question on the Laramie River once and for all. On the basis of the evidence, it seems likely that the Supreme would find it worth while to allot the amount of water to meadowland ranchers, not on basis of acre-feet of water diverted, but rather on basis of acreage involved. Thus, as in the North Platte decision of October 8, 1945, the state of Colorado would be debarred from adding acreage to its irrigated lands on the Laramie River but it would not be limited in the administration of water to land already irrigated. This would mean, then, that the meadowland ranchers could go ahead and use the water according to their needs and priorities and, if this thesis is correct, the flow of the Laramie River in Wyoming would not be materially decreased, so that Wyoming should be willing to accept the decision without further argument. It now seems likely that the interest of the Laramie River ranchers will force reopening the issue and probably the argument will again reach the Supreme Court before so very many more months will have passed. If when the Supreme Court accepts the precedent of the October 8, 1945 decision, a definite system of settlement of many of interstate controversies has been established, and all controversies involving streams in mountain valleys will be susceptible of settlement, where it can be proved that water loss is negligible.

LAND UTILIZATION IN CENTRAL ONTARIO

L. G. Reeds

THE area under investigation lies to the south of the Precambrian Shield and the Kawartha Lakes in Central Ontario. It comprises six townships or 315,000 acres of the best agricultural land of Victoria and Peterborough Counties. It has sufficient variation in land form to provide an interesting study in land utilization. Agricultural land use practices in the drumlinized country near the city of Peterborough differ considerably from those of the much more uniform plain around the town of Lindsay. The purpose of this paper is to point out such variations in land use and indicate their relationship to physical characteristics of the natural environment.

Physiography

The underlying rock of the region is the Trenton limestone series of the Ordovician period. South of the Kawartha Lakes the Trenton cuesta overlies the older harder Black River limestone which borders the Shield.

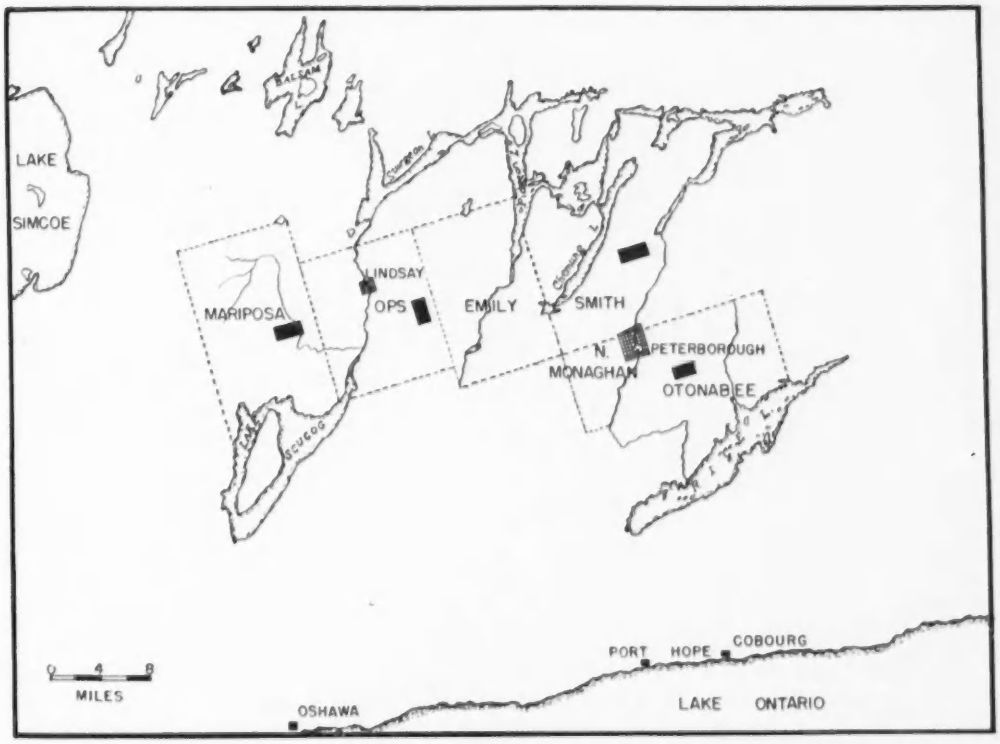

FIGURE 1.—Location map. The six townships—Mariposa, Ops, Emily, Smith, North Monaghan and Otonabee in Victoria and Peterborough Counties, in the lakes district north of Lake Ontario, comprising some 315,000 acres of territory, and illustrating the land uses of the region, constitute the area upon which the present study is centered. Lindsay and Peterborough form the principal urban communities in the area, and are distinguished by environs of different terrain, level and drumlinized respectively.

Bedrock is much nearer the surface in the western part of the region where the drift is only 18 inches in depth in some sections. In the eastern part the drift is quite deep, 100 feet in places.

Most of the area rises about 800 feet above sea-level but some points reach an elevation of 1200 feet. The main surface features are glacial. The Lindsay area is a level lake plain with several small oval drumlins at the margins. Drumlins dominate the landscape in the Peterborough district, where inter-drumlin seepage areas and steep slopes create special problems in land utilization. In the level plain of the Lindsay region, drainage is the most effective hindrance to the agricultural development.

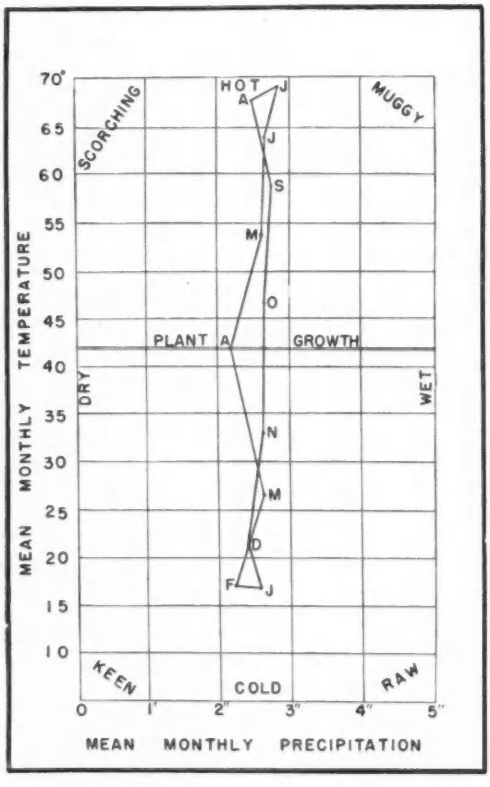

FIGURE 2.—The hythergraph of Peterborough, presenting the mean monthly temperatures and precipitation of Peterborough in graphic form and relationship.

CLIMATE

D. F. Putnam and L. J. Chapman have classified southern Ontario into fifteen climatic regions. The area under investigation has fairly uniform climatic conditions and falls within one zone, "the Simcoe and Kawartha Lakes" region. It differs from the adjoining area to the south bordering Lake Ontario, in that it has a colder winter and a later spring. It receives about 30 inches of rainfall, has a mean annual temperature of 43° F. and has a frost-free period of 130 days. Moisture conditions are fairly trustworthy and adequate for most crops. The Peterborough area, because of its steeper slopes and somewhat lighter-textured soils suffers more from droughts than the Lindsay district. Furthermore, most of the rain comes as thundershowers, resulting in considerable erosion and loss of effective moisture through runoff. A heavy snowfall provides good protection for two important crops in the region, winter wheat and clover.

Winter temperatures are too low for successful fruit-growing. Most orchards are winter-killed. However, the climate is suitable for growth of most general farming crops.

NATURAL VEGETATION

Much original forest cover has been cleared, only 11 per cent of the total area now being occupied by woodland. Many original species have become scarce. Lands of highest agricultural value have the lowest area of woodland. The smallest area in woodland is found in North Monaghan township. Smith township has the largest amount of swamp land. (Figure 3.)

The original vegetation consisted mainly of deciduous hardwoods. The calcareous clay soils of the Lindsay

region once supported a distinctive association in which the most common species were sugar maple, black maple, elm, ash, white cedar, poplar, and willow. Now the dominant species are elm, poplar, cedar and willow. In other parts, the forest was composed chiefly of maple, birch, basswood, elm, yellow birch with some pine, hemlock and cedar. Most of the pine and the more valuable hardwoods have been cut and now a poplar-birch association is commonest. White cedar is found on shallow soils and in swamps. Balsam, black spruce and tamarack are dominant in poorly drained sections.

Dominant grasses are Canada bluegrass, Kentucky bluegrass, and to a lesser extent, red top. Canada bluegrass is most common on heavy clay flats, steep slopes and drumlin ridges. Red top is prevalent in wet areas. On better agricultural soils, most common species are Kentucky bluegrass and white Dutch clover.

SOILS

Soils and topography are most significant factors of the physical environment affecting land use in this part of central Ontario.

The region lies in the grey-brown podzolic soils zone of southern Ontario. Texture of the surface horizon of such soils varies from sandy types in southern Emily and light loams in Monaghan to heavier loams in Otonabee, clays in Ops and mixed clay loams in Mariposa. Physical condition of the loams is good; they are usually friable and more easily tilled than the compact, heavy, calcareous clays.

Soils of Mariposa have numerous small stones, angular in shape and

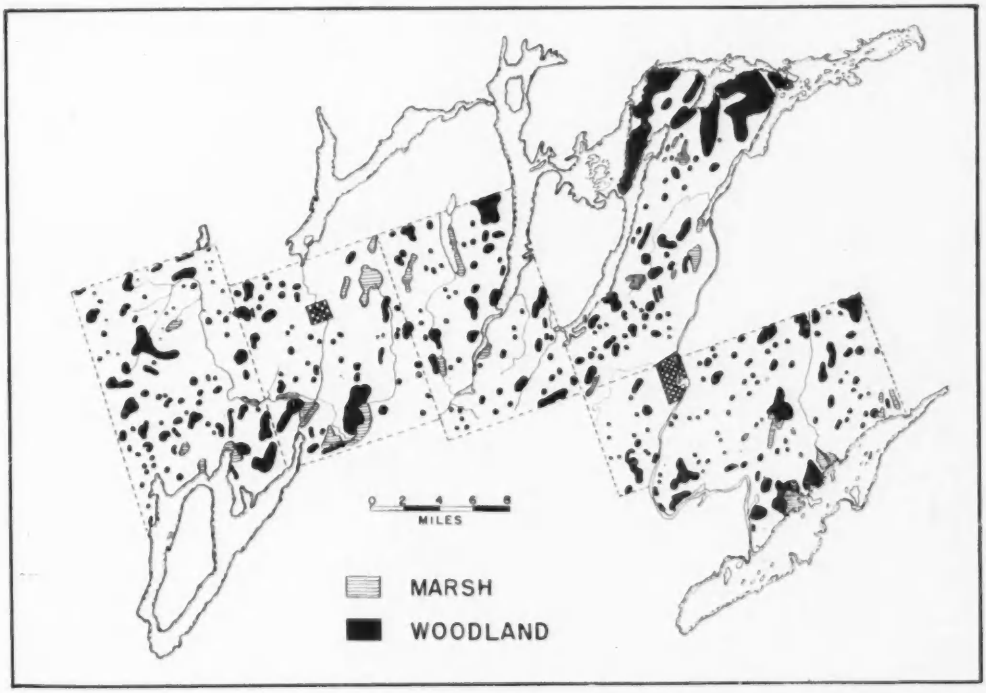

FIGURE 3.—Areas of woodland and marsh. Both marsh and woodland are widely distributed throughout the Simcoe and Trewartha Lakes Region. They represent areas of extensive land use or none at all. Swamps are most characteristic of the Otonabee Land type where they form an outstanding feature of the cover pattern. Woodland is most extensive in the northern part of Smith Township, in the Young Point land type.

derived from the limestone bedrock. The clay area has fewer small stones, although there are some large boulders. Rugged parts of Emily are very stony as are many of the Otonabee drumlins and the area in northern Smith near the Shield.

Trenton limestones which underlie the region have supplied the greater part of the parent materials which have been transported but a short distance. Because of the highly calcareous nature of the parent materials, the soils have a high lime content. The approximate PH of most soils ranges from 7.5 to 8.0. Amount of nitrogen is more variable as it may be altered from year to year by cropping practices. Leficiencies develop on upland soils while the supply is more easily maintained in lowlying clays. All soils are relatively low in available phosphorus and potash. Organic matter content is another variable, but important, element which often determines productivity of the soil, since it provides storage for water and plant nutrients. Sandy morainic areas of southern Emily and soils of steeper drumlins are low in organic matter.

LAND TYPES

Land use is determined to considerable degree by the pattern of soil types. The land type which is a grouping of soil types with similar patterns of surface features probably the most satisfactory is physical basis of land classification for the agricultural geographer. The land type concept was introduced a few years ago by J. O. Veatch of Michigan State College. Veatch pointed out that land of varying potentials for production might be segregated on the basis of the natural land type. His land type is an arbitrary grouping of soil types which have similar profile characteristics, uses, value and crop adaptations.

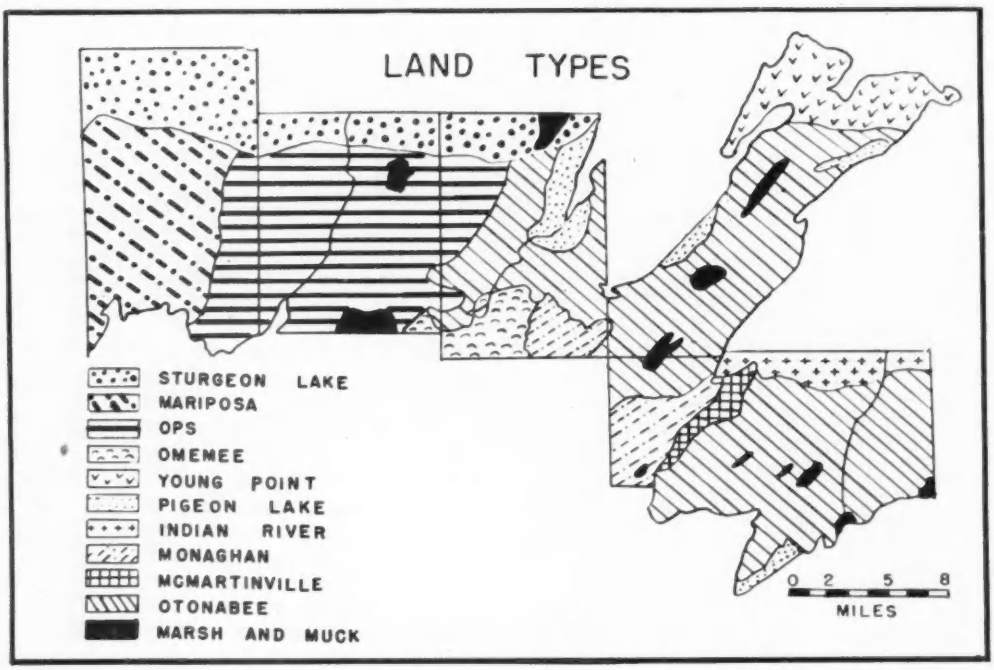

FIGURE 4.—Land types. Land utilization is closely related to the several land types within the general limits set by seasonality of temperature and rainfall, relative fertility of soils, and economic factors, such as accessibility to market.

D. F. Putnam and L. J. Chapman in their land classification surveys of Ontario have used the land type as the unit in mapping.

In this study of a section in central Ontario, many of the dominant features of land use may be related to land type. Other factors, including location and marketing facilities, customs and traditions of individuals or communities were found to be of secondary importance in the explanation of land use patterns.

By grouping main soil types on basis of similar topography, drainage and certain surficial characteristics, eleven land types have been recognized in the region. (Figure 4.)

(*1*) *Sturgeon Lake Land Type.*—This land type which occupies northern portions of Mariposa, Ops and Emily townships, is a level to undulating imperfectly drained area of shallow till over limestone.

It has only medium productive capacity, and consequently the area has experienced mediocre development, although most field crops are grown fairly successfully. Because of shallow soils, the land type is not suitable for intensive cultivation.

(*2*) *Mariposa Land Type.*—Its topography is uniformly undulating. Depressions between gentle surface swells of ground moraine have a thin veneer of lacustrine deposits. The drift which

TABLE I

LAND CLASSIFICATION

I. *Till Plains:* Land surface characterized by deposits of limestone boulder clay

Acreage	*Per Cent of Total Area*		
163,950	33	(a) Otonabee Land Type:	Rolling to hilly drumlinized till plain with intermediate-textured deposits.
12,600	4	(b) Monaghan Land Type:	Rolling till plain with light-textured well-drained till deposits.
28,350	9	(c) Mariposa Land Type:	Undulating till plain with shallow deposits of fine-textured till mixed with lacustrine material over limestone. Numerous small angular fragments of the bedrock appear in the surface deposits.
9,450	3	(d) Indian River Land Type:	Level to gently undulating poorly drained till plain.
37,800	12	(e) Sturgeon Lake Land Type:	Undulating shallow till deposits over limestone.
15,750	5	(f) Young's Point Land Type:	Undulating very shallow till deposits over limestone with numerous large boulders on the surface.

II. *Lacustrine Plains:* Characterized by level to undulating topography and water-laid deposits

Acreage	*Per Cent of Total Area*		
72,450	23	(a) Ops Land Type:	Level to undulating lake plain with heavy lacustrine deposits over till.
3,150	1	(b) McMartinville Land Type:	Level to gently undulating imperfectly drained heavy-textured deposits of deltaic origin.

III. *Sand and Gravel Hills:* Characterized by more or less hilly topography and coarse-textured deposits

Acreage	*Per Cent of Total Area*		
12,600	4	(a) Omemee Land Type:	Characterized by rolling to steep and hilly land with sorted coarse gravel and sandy deposits.
9,450	3	(b) Pidgeon Lake Land Type:	Level to undulating coarse sandy deposits.

generally tends to be shallow, is characterized by numerous small angular fragments of limestone bedrock on the surface. The soils are high in lime and in spite of their shallowness have very high productive capacity, being especially well adapted for wheat and clovers.

(3) *Ops Land Type.*—Much of the central part of Ops township and a section of eastern Mariposa is a level to gently undulating plain with lacustrine deposits of clay over till. Level tracts are to be seen around the town of Lindsay. A few small oval drumlins occur at margins of the type.

Two physical characteristics which tend to cause problems in tillage and production are heavy texture of the soils and imperfect drainage. A compensating factor in dry seasons is their resistance to drought consequent upon colloidal properties of the clay particles. Chemically, they are high in lime and nitrogen. Organic matter and potash content are usually adequate to meet plant requirements. There is, generally, deficiency of phosphorus, which may be supplied most economically by application of superphosphates.

Productive capacity of the type is high. The heavy clay soil is suitable for production of hay and forage crops and, when adequately drained, gives high yields of grain.

(4) *Omemee Land Type.*—It comprises the rugged morainic hills of southern Emily township. Stones are numerous, many having been piled on hillsides or built into fences. Drainage is excessive and there has been considerable erosion. The soils are low in natural fertility, having little available potash, phosphorus and nitrogen and especially deficient in organic matter.

Agricultural value of the land is depreciated by steep slopes, stoniness, susceptibility to erosion and by soils low in natural fertility. The steep stony sections are difficult to cultivate and crop yields are low. Large areas are used only for pasture. Pastures dry out early in the summer and have low carrying capacity. Several farms have been abandoned. They are mainly useful for sheep ranches. The most suitable crops for the type are potatoes, rye and sweet clover.

(5) *Pidgeon Lake Land Type.*—Closely associated with the Omemee type with respect to inherent physical characteristics, are several small scattered sand

FIGURE 5.—Drumlinized country southeast of Peterborough. Slopes here are often 15 per cent or over. Otonabee land use type study (A) is located to the left of the road shown.

plains along the shores of Pidgeon, Chemung and Rice Lakes.

The Pidgeon Lake section is poorest and maintains only a subsistence type of agriculture. The Rice Lake area is not cultivated extensively. A large section is occupied by the Hiawatha Indian Reserve. Cultivated land is used mainly for vegetable gardens.

(*6*) *Young's Point Land Type.*—Bordering on the Precambrian Shield in northern Smith, is an area characterized by shallow limestone moraine strewn with numerous limestone and granite boulders.

Agriculturally, it has many disadvantages. Drainage is imperfect because of shallowness of the drift. Because it does not provide good pasture for cattle it is used mainly for sheep. Inaccessibility is another limiting factor to agricultural development. A large percentage of the area is woodland. Much cleared land should be reforested.

(*7*) *McMartinville Land Type.*—It prevails southeast of Peterborough along the Otonabee River, an area formerly submerged in the waters of glacial Lake Iroquois. McMartinville is characterized by level to gently undulating topography, imperfectly drained, stone-free, lacustrine soil, alkaline in reaction and high in organic matter content. Because of heavy texture the soils tend to bake into large clods.

Under proper management, the type produces good crops of cereals, roots, silage corn and hay.

(*8*) *Indian River Land Type.*—Occupying the northern part of Otonabee township is this imperfectly drained associate of the Otonabee land type. The soils are stony and alkaline with fairly high organic matter content. Agricultural development is limited. There are few good farms. Most of the area is swamp, although a small part is pasture and a smaller percentage is drained and cultivated. The region serves as a reservoir for water and assists greatly in maintaining the water table of adjoining sections at adequate level.

(*9*) *Monaghan Land Type.*—Comprising a large proportion of North Monaghan and parts of southeastern Emily, the type possesses an ideal undulating to gently rolling topography. The soils are well-drained, calcareous, light-textured loams which have a medium organic matter content, and excellent physical condition. They are easily tilled and highly productive.

FIGURE 6.—Hilly topography of the Omemee land type. A large percentage of the steep slopes is in pasture. Sheep may be seen grazing in the background.

For general agriculture, it ranks very high and has been very well developed.

(*10*) *Otonabee Land Type.*—Occupying large sections of Otonabee, Smith and Emily townships, it comprises 33 per cent of the total area of the region. It is composed of well-drained drumlin ridges, which range from rolling to hilly, and poorly drained seepage areas between.

Sheet erosion characterizes steeper drumlins, although it is less severe than on similar slopes in other regions. Clay content of the soils and the highly calcareous nature of the parent materials have tended to retard erosion.

The Otonabee loam is the dominant type on rolling, well-drained uplands. The Otonabee loam is an immature podzolic soil. The leaching process has been delayed by the calcareous quality of the parent material. Under natural forested conditions, the A_1 horizon is a dark coloured loam varying in depth from 2 to 4 inches. It has a granular structure, a high humus content and is alkaline in reaction. The A_2 is not an intensively leached layer. It consists usually of 3 to 5 inches of coarsely granular, greyish loam. The B horizon is about 1 to 2 inches in depth. It is a coffee brown clay loam with nutty structure. Generally at less than 15 inches from the surface, the C horizon consists of grey calcareous till containing numerous small rounded pebbles and large limestone boulders.

The Otonabee loam displays a youthful profile and greater affinities with the brown podzolic soils of eastern

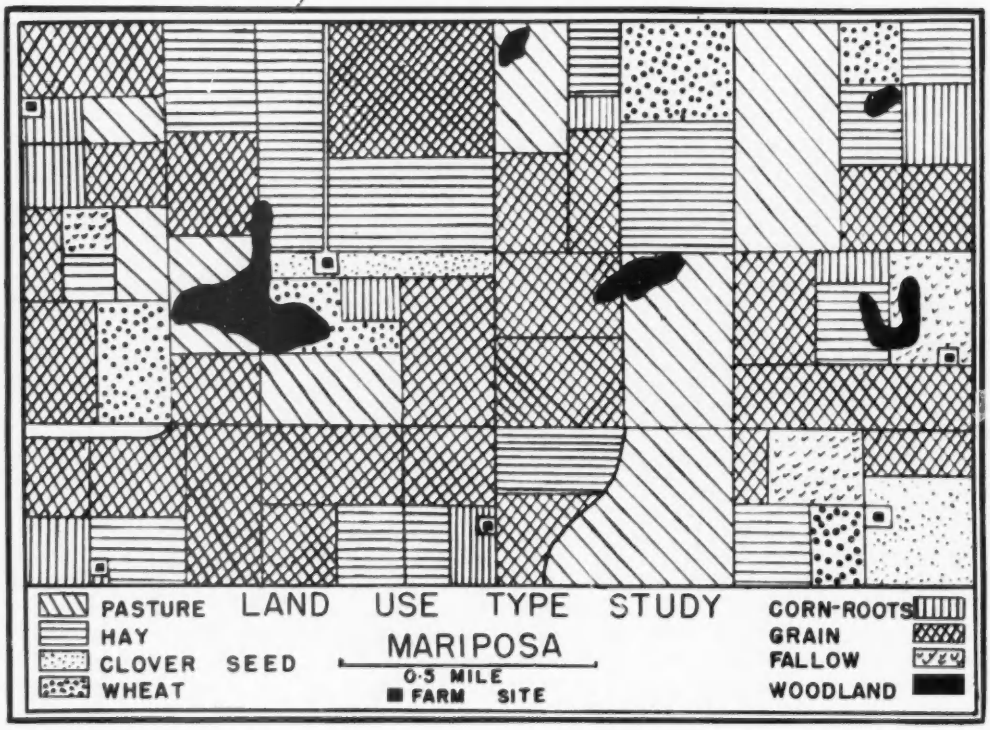

FIGURE 7.—Mariposa Type Study. Land use in the Mariposa quadrangle chosen for detailed and exhaustive study. The varied pattern indicates the diversity of agricultural production in the area. The terrain is an undulating till plain. The soils are derived from fine-textured till mixed with lacustrine sediments over limestone, of which small angular fragments are numerous in the surface soils.

Ontario than with the grey-brown podzolic soils of central and south-western Ontario.

The Otonabee land type is the most diversified, comprising several soil types developed under different drainage conditions and slope. Agricultural development is variable. Some of the best

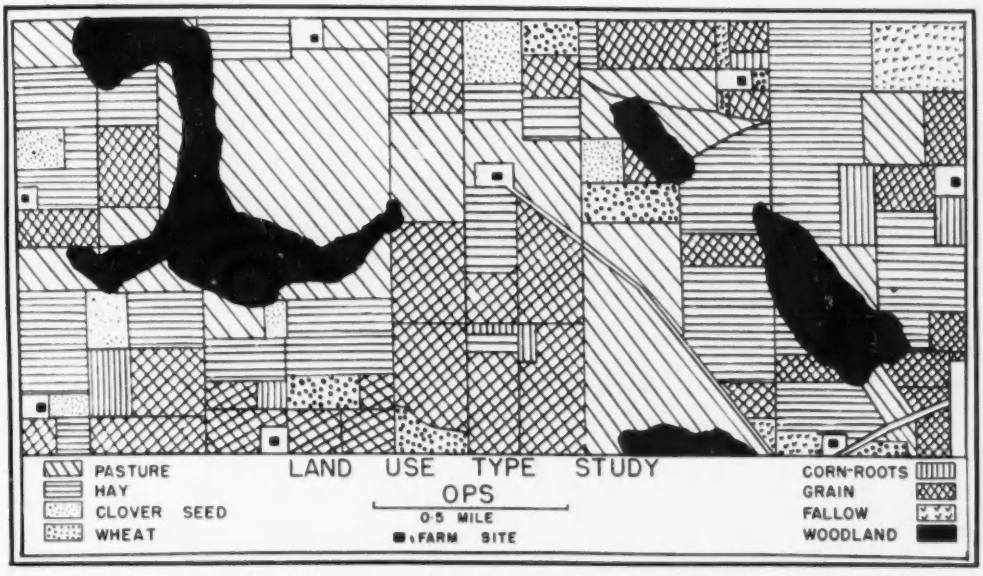

FIGURE 8.—Ops Type Study. Land use in the Ops quadrangle of special study where the terrain is level to undulating lake plain with heavy lacustrine deposits over till. Imperfect drainage and heavy texture of the soils form serious problems; when adequately drained the type represents high productive capacity, especially of hay and forage crops.

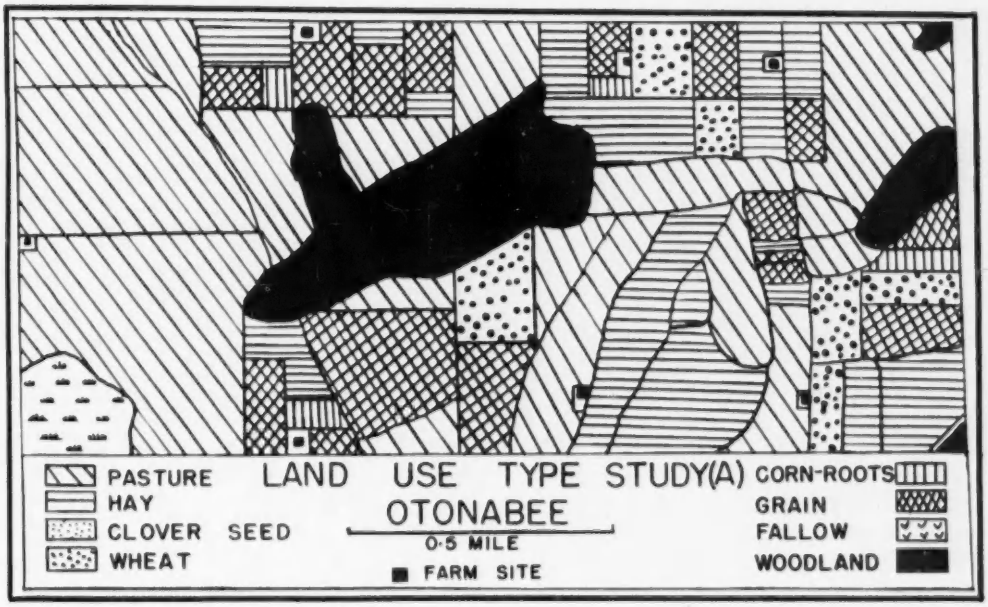

FIGURE 9.—Otonabee Type Study (A). The Otonabee type quadrangle is typical 33 per cent of the total area. The Otonabee loam, an immature podzolic soil, is the dominant soil of the area. Agricultural use of the land varies considerably in conformity with similar variety within the land type; the area includes some of the best farms and some of the poorest.

and some of the poorest farm lands are found in the Otonabee land type. Several drumlins are too steep for cultivation. The inter-drumlin seepage areas can be utilized only great difficulty. Many such sections have not been drained and are left in swamp. The rolling uplands have good drainage and have experienced fairly high development of mixed farming. The soils

the Grand River Valley of Western Ontario. The writer wishes to throw some further light on agricultural land use in peninsular Ontario. He presents information based on field work carried out during the summer of 1941. Sample areas of 1,000 acres were selected in each of the land types and studied in detail. Four such type studies will now be discussed.

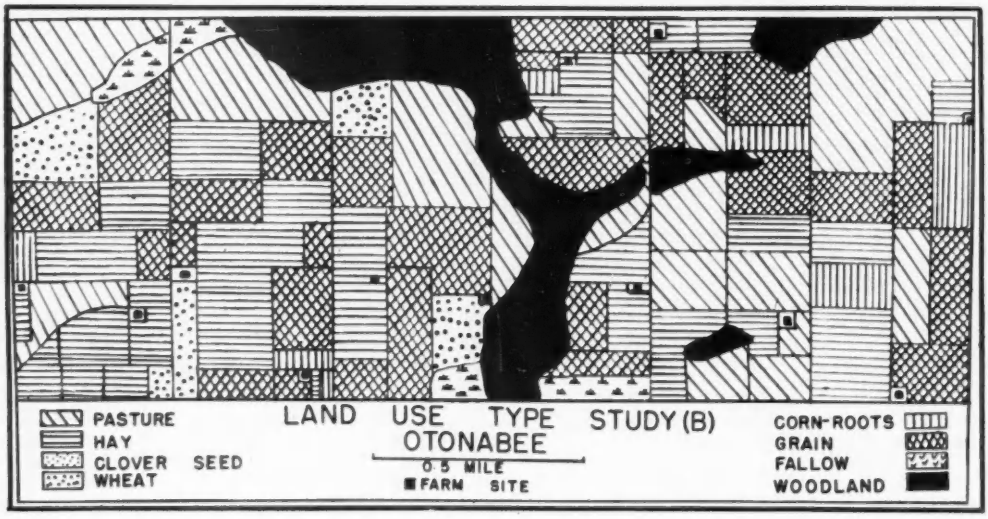

FIGURE 10.—Otonabee Type Study (B). The Otonabee type quadrangle varies from type (A) in its larger proportion grain crops and hay, with relatively smaller areas of pasture, and of wheat. Similar diversity characterizes both, in terrain, soil, and crops.

are well adapted for general agriculture. Winter wheat, oats, barley, clovers, alfalfa, roots and corn are produced in large quantities.

(*11*) *Marsh and Muck Type.*—In the Lindsay region, the type occurs as swampy marshes of bush willows, pastured during summer. Since they cannot be drained easily, they may be regarded as submarginal land.

In the Peterborough district, similar areas occur as floodlands along lakes and larger streams.

LAND UTILIZATION

C. F. Lee, in a previous paper (ECONOMIC GEOGRAPHY, Vol. XX, April, 1944), has described land utilization in

MARIPOSA TYPE STUDY

The dominant characteristic of this type is the high percentage of improved land (85 per cent), only 4 per cent being woodland. Highly productive capacities of the Mariposa land type have led to its intensive utilization. A five-year crop rotation is being practised, i.e., wheat, clover, roots and corn, hay and grain. Yields of grain are usually fairly high. The root crop and corn acreage of 7 per cent is highest of any sample area studied, resultant upon making the root and corn crop an integral part of the rotation.

Area in grain (27 per cent) is about average for the land type. Oats and

FIGURE 11.—Erosion on a drumlin in Otonabee township. (Photo, courtesy of D. F. Putnam and L. J. Chapman.)

barley grown separately are more common than mixed grain. Clover seed and fall wheat are important crops. The soil is well adapted to growth of alsike and other clovers. For many years clover seed has been a leading cash crop in the district.

Beef cattle form the predominant type of livestock, although sheep, hogs and poultry are kept in large numbers. Dairying has not been developed to any extent. The level topography lends itself to mechanized cultivation. Many tractors and several combines are being used.

The type gives a fair representation of the agricultural economy of the region. However, certain parts of the Mariposa land type are more poorly drained and have higher acreages in pasture.

OPS TYPE STUDY

Located in the eastern part of the Ops land type area, the sample has a few small drumlins to add some relief to an otherwise flattish clay plain. Chief limit to utilization of the section is poor drainage in low-lying flats.

Occupying 14 per cent of the total area of 1,050 acres are patches of swampy woodland, in which the chief species of trees are elm, poplar and cedar. The bush lands serve as partial

FIGURE 12.—Strip-cropping in Otonabee. Sod is an effective means of controlling erosion on steep sides of drumlins. Many farmers, however, continue to cultivate steep slopes and to plough up and down the drumlins.

source of fuel and also for pasture. Twenty per cent of the area is pasture, a high proportion partly due to recent transfer of an entire farm from cultivation to ranching. Large quantities of mixed hay are grown for winter feeding of dairy cattle. Alfalfa grows well on small drumlins. Winter wheat is confined mainly to higher and drier fields where yields up to 40 bushels per acre are being obtained. Acreage in grains (176 or 17 per cent) is lower than average for the land type. Mixed grain bulks largest, practically all used for feeding purposes on the farm. Many dairy farmers supplement their home-grown grains with commercial feeds higher in protein content. Alsike has been grown for many years, although acreage is declining because of lower prices and poorer yields. The area given to corn and roots or left fallow is small, partly because of shortage of labour. No regular form of crop rotation is practised, although many grow grain (1 year), clover (1 year), and timothy or alfalfa for about 4 years.

Dairying is the predominant type of farming. Five of the seven occupied farms in the sample area have good quality herds of Holstein cattle producing milk for the Toronto market. Hogs and poultry provide supplementary sources of income. Specialization in dairying has been developing in Ops since 1925. However, general farming is dominant in the southeast and northwest, whereas beef-raising is common in sections adjoining Mariposa. Most type study farms have good equipment.

FIGURE 14.—Otonabee loam profile.
A_1 horizon—2–4 inches of dark colored loam.
A_2 horizon—3–5 inches of coarsely granular grey-brown loam.
B horizon—1–2 inches of coffee-brown clay loam.
C horizon—grey calcareous loamy till containing numerous small rounded pebbles and large limestone boulders.
(Photo, courtesy of D. F. Putnam and L. J. Chapman.)

FIGURE 13.—Inter-drumlin swamp common in Otonabee and Smith townships. Such seepage areas constitute one of the major limits to the agricultural development of the Otonabee land type.

Poor drainage is the chief limitation to agricultural development. It could be improved considerably by cleaning out and deepening open drainage channels and by installation of more tile drains.

Productivity of the area in permanent

pasture would be improved by cultivation and re-seeding to alfalfa. There is tendency toward excess growth of weeds in some parts of the land type, which calls for a more intensive cultivation in midsummer or complete fallow. Fertility of the soil is being maintained satisfactorily.

Figure 15.—Mixed grain on the level clay plain near Lindsay.

Otonabee Type Study (A)

This type study forms a good example of the steep phases of the Otonabee land type with slopes of 15 per cent and over. The sample area includes parts of eight drumlins. In the southwestern part there is some flatter kame material which is utilized for road-building. Good surface drainage is found under such topographical conditions while good internal drainage is insured by the pervious stony till.

Land use and field patterns are closely related to topography. Arrangement of fields in the eastern part reflects the northeast southwest pattern of the contours. The outstanding feature is the high acreage in pasture (37 per cent). The flanks and tops of steeper drumlins are unimproved pasture. A strip of sod has been adopted as measure of controlling erosion on the side of one of the drumlins. Cultivated areas are confined to valleys and less steep uplands. Sixteen per cent of the total area is swamp, produced largely by seepage from the surrounding ridges. The upland soils have fairly high productive capacity. Rugged topography accounts for low acreage in grain, 120 acres or 15 per cent of the total. Sixty-three acres were in wheat in 1941 and yields were about 30 bushels per acre. Only 35 acres of roots and silage corn were grown and no land was utilized for clover seeds or left in fallow. In the 160 acres of hay there was very little clover or alfalfa, although the crops would yield well on this land type.

Agricultural development of this sample area has been limited by the topography. The original land survey cuts across the grain of the country. Farm lots include sections of several drumlins. More time to the acre is required for performing farm operations on such steep, irregular fields. The large, level rectangular fields of the Ops land type stand out in contrast and give greater economy of fencing and labour.

Figure 16.—A field of buckwheat, a crop commonly grown on the poorly drained sections of the Ops land type.

General farming is practised. Much of the land is suitable only for pasture or woodland. Farm buildings are small and many in need of repair. Its numerous drumlins give the landscape a unique appearance but do not display very prosperous agricultural development.

OTONABEE TYPE STUDY (B)

Topography of the section varies from undulating in the east, to flat in the centre, and rolling in the west. In accordance with topography, drainage varies from poor to excessive. Otonabee loams are found in the western sector, muck in the central area, Farmington loams in the eastern part with some sandy loams and sand in the north-west. The Farmington loam is a shallow, droughty, stony soil developed on limestone. The type occurring here is better than most Farmington loams.

There is very close correlation between soil type and land use. The area in permanent pasture, consisting of 298 acres or 25 per cent of the total 1,225 acres, is determined to large extent by soil type. Eighty-five per cent of the pasture is located in the Farmington loams and sandy soils. Crop yields are below average because of deficiency of humus and mineral matter content in the soils. The winter wheat acreage, 65 acres, is confined entirely to the Otonabee loams which have good water-holding capacity and fairly high organic matter content. The muck and wet sandy loam area of 175 acres is covered with bush, main species being spruce, pine and cedar. One field in this part of the sample area is in buckwheat. The north-west corner with its lighter-textured soils has been pasture for many years. The acreage in hay (25 per cent) is more equally distributed. The topography and soils of the eastern section are well adapted to growth of alfalfa.

FIGURE 17.—A crop of wheat on Ops land type. The yield from this field was 40 bushels per acre.

Specialization is lacking in the area. Beef cattle, poultry and hogs are kept in varying numbers. One dairy herd in the northern part is producing milk for the nearby town of Lakefield. Farm buildings are fair but equipment is poor. There are no tractors being used and no farms have hydro-electric power.

Physical limitations have been important in determining development of the area. Location is also a significant factor. The stimulus offered by proximity to markets has accounted for more intensive utilization of similar areas near the city of Peterborough.

From the two samples of the Otonabee land type, one might be inclined to conclude that drumlinized country is usually second-rate agricultural land. On the contrary, many of the soils developed on the calcareous tills are highly productive. In areas where drumlins are not too steep, as in the rolling countryside surrounding the village of Keene, there is a very prosperous agricultural community.

GENERAL ASPECTS OF THE AGRICULTURE

O. E. Baker in his classification of the agricultural regions of North America has included this area within the Hay and Dairy belt. R. Hartshorne and S. Dicken classified it as a Hay-Pasture-Livestock, meat specialty, region. D. S. Whittlesey has defined it as a part of a Commercial Livestock and Crop Farming region.

On the basis of systematic field traverses and analysis of census data, the writer would label this section of central Ontario as a region of general farming with emphasis on rearing livestock and producing milk for fluid

FIGURE 18.—Farm near Oakwood in Mariposa with a large field of silage corn, mangolds, turnips and potatoes. The crops form an integral part of the rotation in this district.

purposes. Growing grain as a cash crop is not significant. Most all crops grown are fed to livestock on the farms. Animal units per square mile average 178.

Although agricultural types cannot be defined very clearly within this small area of six townships, certain areal distinctions can be recognized. There is a slight concentration of beef-raising in Mariposa, particularly in the vicinity of Oakwood and Little Britain. The sale of milk for fluid purposes provides main source of revenue in a belt of territory extending through central Ops. Market gardens form a narrow fringe around the city of Peterborough. Figure 19, the milk shed of the city of Peterborough, shows the dairying zone near the urban centre. Circles drawn with radii of 2 to 4 miles emphasize the localized nature of the milk shed.

Sixty-eight per cent of the farm land is improved. Although lower than in parts of western Ontario, it compares favourably with most of central Ontario. Of the 315,000 acres of occupied land, 51 per cent was crop land, 29 pasture, 11 woodland, 20 fallow, 7 marsh and waste land.

The average size of farm is 125 acres. The land (i.e. improved land) to man ratio varies from 12 in North Monaghan to 23 in Ops with the average being 20. Farm incomes range from $500 to $7,000, the average being approximately $1,200. During the last 20 years there has been a trend toward fewer owners and more tenants, to greater extent on better land types.

In order that present development of the region might be presented taxonomically, land classes were mapped. The appearance of buildings and equip-

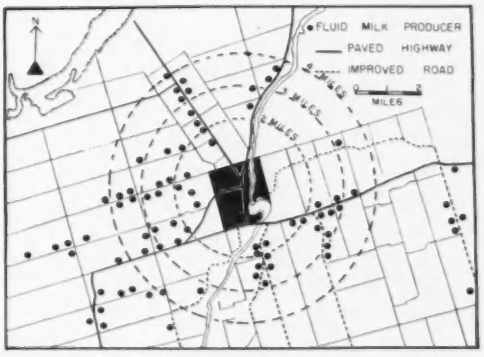

FIGURE 19.—Milk shed of the city of Peterborough. Areal distribution of farms supplying fluid milk for the Peterborough urban community reveals the critical importance of proximity, and of good roads for quick transportation in fluid milk marketing.

ment, and the production that was being obtained were used in determining the three land classes (Figure 20). Farms in Land Class I have good buildings and equipment and show fairly high production. In Land Class II farms have a fair appearance with somewhat poorer equipment. Land Class III displays a depressed appearance with many buildings needing repair.

Mariposa has a large area in Land Class I because of productive soil and successful specialization in wheat and clover seeds. Inadequate drainage and greater distances from highways have hindered development in other sections of the township.

Emily has a small area of Land Class I, partly because of lack of progressiveness, characteristic of the Irish Catholics who constitute 80 per cent of the rural population in the township. However, a well-developed agricultural community surrounds the parish centre of Douneyville. The hilly Omemee land type is inferior

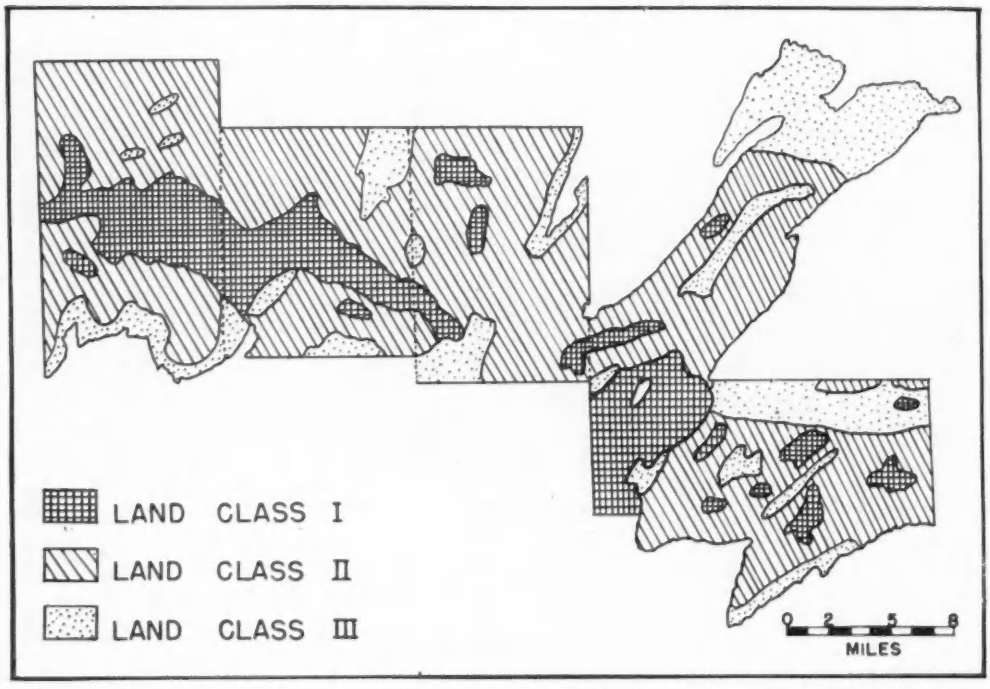

FIGURE 20. Land Classification. Distribution of land classes based upon the criteria of state of buildings and equipment, and production and yield, of farms. Land Class I is characterized by superior buildings and equipment and fairly high yield; Class II by fair buildings and inadequate and inefficient equipment; Class III by buildings in need of repair and paint, and depressed farm appearance suggesting marginal production or management.

Land Class III in this township occurs in the areas of muck.

Ops has a relatively large area in Land Class I, controlled by better drained clay sections, good transportational facilities and partial specialization in dairying. agricultural land and has several farms of the pioneer subsistence type.

Smith township displays variety of development from goat-rearing in the north to modern farms equipped with combines

FIGURE 21.—A herd of dairy cattle on alfalfa pasture near Reaboro in Ops township. Many farmers in this vicinity keep Holstein cattle for the production of milk, which is shipped by truck to Toronto.

near Peterborough. The Young's Point land type is inherently poor, thus limiting development of the northern section for agriculture. Some land in central Smith would have been better developed had it been more favourably located with respect to good roads and markets.

Unfavourable topography and large swamps account for Land Class III areas in Otonabee. The Indian River land type is an unproductive section. The areas of less slope in most cases have experienced better development.

North Monaghan has the greatest uniformity and the largest percentage in Land Class I. The vital controls are productive soils, favourable topography, good drainage and proximity to the city of Peterborough.

SUMMARY AND CONCLUSION

Many of the significant characteristics of the land use in the region are related directly to the land type. The relationships that were recognized are enumerated below.

1. The outstanding feature of cover pattern in the Otonabee land type is the large proportion of swamp.

2. Soils of the Mariposa land type have favoured growth of wheat and clovers.

3. Clay soils of the Ops land type have produced large quantities of forage crops essential to dairy industry.

4. Pasture is the dominant form of land use in the excessively drained, hilly Omemee land type.

5. An extensive utilization characterizes the Young's Point land type with its shallow, stony soils.

6. Small herds of poor quality cattle are common in the areas which are less intensively utilized as in the Omemee, Pidgeon Lake, and Indian River land types.

7. Mechanized cultivation has been followed to greater extent in the more nearly level areas in Ops, Mariposa and North Monaghan townships.

8. The largest farms are found on poorer land types, with exception of Mariposa which has several large ranches.

9. Non-resident farms are most common in Omemee, Otonabee and Mariposa land types.

10. Farm tenancy is highest in Mariposa and Otonabee.

11. The best farm buildings are in Mariposa and Monaghan land types.

12. Farm incomes are higher in Mariposa, Monaghan and Ops than in Omemee, Pidgeon Lake, Young's Point or Indian River land types.

Thus agricultural land use in this part of central Ontario has been conditioned

greatly by the physical factors of the natural environment. In this small area of 315,000 acres, the fundamental factors of climate and the nature of the underlying rock do not vary significantly. An explanation of the variations in land use must be referred to other sources. The influence of the human element should not be overlooked and may be seen in the economic land classification. Land type, however, as outlined in this paper, appears the most satisfactory basis for evaluating agricultural resources of the region. Two most important single factors of the land type concept are topography and drainage. Topography forms the vital control in the Peterborough district where the utilization of steep slopes has been the outstanding problem in agricultural development. Drainage is the dominant factor in the Lindsay region where large-scale drainage projects are needed to increase agricultural production. Welfare of the rural population throughout the region would be improved greatly if the agricultural land use practices were in closer harmony with the basic pattern of soil and surface features.

BOOK REVIEWS

NEW ZEALAND DEPARTMENT OF INTERNAL AFFAIRS, HISTORICAL BRANCH. *Introduction to New Zealand*. 271 pp. Whitcombe & Tombs, Ltd., Wellington, N. Z., 1945.

CUMBERLAND, K. B. *Soil Erosion in New Zealand*. 227 pp. Whitcombe & Tombs, Ltd., Wellington, N. Z., 1944.

Indicative of the growing inter-relationship between America and New Zealand, the two books hereby reviewed, one general, the other specialized, have more than ordinary interest for the American Geographer. Both have appeared from the press in relatively recent time, and thus are definitely opportune.

"Introduction to New Zealand" is essentially a handbook that systematically and comprehensively attempts to give a complete and integrated picture of the New Zealand land and folk. Obviously, it is a compacted description, carefully organized and of carefully selected materials. Only the essential and important facts and principles are elaborated, and while there is adequate detail for full understanding of the country and its people, irrelevant or inconsequent matters are omitted. As a result it forms a most valuable reference volume on the country, which will endure as a source book for many years to come.

The contents of the volume give perhaps the best clue to its character and its value. It is composed of nine chapters: 1. The Face of the Land; 2. New Zealand History; 3. The Rule of Free Men; 4. Economics of the Dominion; 5. Pacific Peoples (Particularly the Maori); 6. The New Zealand Mind; 7. Beasts and Flowers; 8. Manly and Womanly Sports; 9. Fighting a War; a brief but catholic list of books relating to New Zealand; and at the end, an excellent physio-cultural map.

It is an excellent book for the American reader. Its purpose is best expressed by the following quotation from the foreword: "Here is a book about New Zealand. It is not, we hope, a superfluous book, or a vainglorious book, or a flowery book, or a contentious book. It aims at plain and modest statement. Nowhere in these pages will you find New Zealand confused with Paradise. We don't make absurd claims for our country. It is a little country. It is a young country; in terms of Western culture, it is no older than the states of Iowa or Wisconsin." . . . "We think it is a beautiful country. We don't say that it is more interesting or more beautiful than the United States. We don't want to seem conceited; but we don't want to be too absurdly humble either. And we think our country is beautiful and interesting, and as we have written this book in answer to suggestions from our American friends, we think Americans will probably be interested in it."

"Soil Erosion in New Zealand" is a much more specialized book published under the authority of "The Soil Conservation and Rivers Control Council," an administrative agency set up by the government, though that agency accepts no responsibility for the statements made in the book, and expressly states that it does not necessarily agree with all the opinions expressed by the author, though it does put its stamp of approval upon it.

The author has written an excellent book, a convincing book, a serviceable book, particularly valuable to New Zealand people and their economy and politics. The significance of the book is perhaps best suggested by a quotation from the author's opening "Apologia": "It seems highly probable that New Zealand, the youngest of the British Dominions, has a soil erosion problem of greater significance in its relation to the future well-being of the country than has any one of the older members of the Commonwealth. The superficial area of New Zealand is small; its history of European occupance and exploitation short. The national economy and the individual living standards of its million and three-quarter people reveal an emphatic dependence upon a restricted range of export commodities—all derived from the utilisation of the soil. And New Zealand has few other significant resources."

The soil erosion problem of New Zealand is considered regionally, and particular attention is paid to four regions of North Island, and four regions of South Island, with which the first half of the book is concerned. The general problems of the country are then taken up in the conclusion, and in five extensive appendices. It is a well integrated, and well presented, argument for immediate control of erosion in the country, as convincing as it is clear and forceful.

W. E. E.

VÍLA, PROFESSOR PABLO. *Nueva Geografía de Colombia*. Aspectos Politico, Fisico, Humano y Economico. Libreria Colombiana. Camacho Roldan & Cia., Ltda., Bogotá, 1945. 358 pages.

Professor Pablo Víla, a native of Catalonia, who has lived for almost a decade in Colombia, has written a geography of his new *patria*, "Una Nueva Geografía de Colombia" (Bogotá, 1945). In it he treats in a masterly way the political, physical, human and economic aspects of the country. He devotes an excellent historical chapter to the Magdalena River, which was for so long the economic life line of the country. In the section dealing with agriculture, the backbone of Colombian economy, he reaches the significant conclusion that "technical progress will not be possible without the aid of government credit to the farmer, and without the organization of a producers' coöperative such as exists in the coffee industry." (P. 266.) The gradual unfolding of the economy of the country is pictured in detail: first a glimpse of the pre-Colombian cultural landscape; then, in proper perspective, the Spanish colonial regime, which constricted the life of the country like a straightjacket; lastly, modern Colombia, with its factories and its railroads, its oil fields and its air service—the whole presented in such an authoritative and interesting manner as to have a lively appeal for the general reader and the social scientist as well as for the student and the classroom. The volume contains scores of richly illustrative photographs and charts, and each chapter is accompanied by an exhaustive bibliography, which makes it indispensable to those who are concerned with Colombian problems. This work, in its scope and general excellence, is unique of its kind in the Latin American world, and geographers of the other republics would do well to use it as a model.

RAYMOND E. CRIST

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